AD-E300 545

LEVEL III

DNA 4702F

NUCLEAR WEAPON EFFECTS CALCULATIONS IN THE TACWAR CODE

Systems, Science & Software, Inc.
The Atrium, Suite 202
277 S. Washington Street
Alexandria, Virginia 22314

20 October 1978

Final Report for Period 20 March 1978–20 September 1978

CONTRACT No. DNA 001-78-C-0221

THIS WORK SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B364078464 V99QAXNL12258 H2590D.

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

Destroy this report when it is no longer needed. Do not return to sender.

PLEASE NOTIFY THE DEFENSE NUCLEAR AGENCY, ATTN: TISI, WASHINGTON, D.C. 20305, IF YOUR ADDRESS IS INCORRECT, IF YOU WISH TO BE DELETED FROM THE DISTRIBUTION LIST, OR IF THE ADDRESSEE IS NO LONGER EMPLOYED BY YOUR ORGANIZATION.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	DNA 4702F
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	NUCLEAR WEAPON EFFECTS CALCULATIONS IN THE TACWAR CODE
5. TYPE OF REPORT & PERIOD COVERED	Final Report for Period 20 Mar 78– 20 Sep 78
6. PERFORMING ORG. REPORT NUMBER	SSS-R-79-3810
7. AUTHOR(s)	John W. Cane John A. Northrop
8. CONTRACT OR GRANT NUMBER(s)	DNA 001-78-C-0221
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Systems, Science & Software, Inc. The Atrium, Suite 202, 277 S. Washington Street Alexandria, Virginia 22314
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	Subtask V99QAXNL122-58
11. CONTROLLING OFFICE NAME AND ADDRESS	Director Defense Nuclear Agency Washington, D.C. 20305
12. REPORT DATE	20 October 1978
13. NUMBER OF PAGES	132
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS (of this report)	UNCLASSIFIED
15a. DECLASSIFICATION DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B364078464 V99QAXNL12258 H2590D.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Algorithms	Nuclear Warfare	Targeting
Computer Aplications	Nuclear Weapons	War Games
Military Applications	Operations Research	Weapons Effects
Military Operations	Simulation	
Nuclear Radiation	Tactical Warfare	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The study reviewed the accuracy of nuclear weapon effects data and algorithms used by the IDA TACWAR theater warfare simulation computer model to make damage evaluations. The report describes areas where improvements in specifying the nuclear explosion-generated effects--nuclear radiation, thermal radiation, and air blast--could be made.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

PREFACE

The authors wish to express their gratitude for the active assistance and cooperation of the following individuals, without whom this investigation would have been far less efficiently executed: Mr. Edward P. Kerlin, Dr. Leo A. Schmidt and Dr. Dale L. Moody of the Institute for Defense Analyses, and Captain Randall B. Saylor (USAF) of the Defense Communications Agency's Command and Control Technical Center.

CONVERSION FACTORS FOR MEASUREMENT UNITS

TO CONVERT FROM	TO	MULTIPLY BY
cal (thermochemical/cm^2	megajoule/m^2 (MJ/m^2)	4.184000E-2
foot	meter (m)	3.048000E-1
inch	meter (m)	2.540000E-2
kilotons§	terajoules	4.183
kip/inch^2 (ksi)	kilo pascal (kPa)	6.894757E+3
mile (international)	meter (m)	1.609344E+3
rad (radiation dose absorbed)	gray (Gy)*	1.000000E-2

* The gray (Gy) is the accepted SI unit equivalent to the energy imparted by ionizing radiation to a mass of energy corresponding to one joule/kilogram.

TABLE OF CONTENTS

Section		Page
	PREFACE	1
	CONVERSION FACTORS FOR MEASUREMENT UNITS	2
	TABLE OF CONTENTS	3
	LIST OF ILLUSTRATIONS	5
	LIST OF TABLES	7
I	INTRODUCTION AND SUMMARY	9
II	DETAILED DISCUSSION OF SUBROUTINES	16
	2-1 DAMEVL	16
	2-2 DOSLIM	18
	2-3 FN	18
	2-4 PREFN	19
	2-5 QKINR	20
	2-6 WRAD	35
	2-7 WRADVN	37
	2-8 OFFCOV	41
	2-9 SIMCN	49
	2-10 SIRCOV	53
	2-11 CIRCOV	67
	REFERENCES	73
Appendix		
A	FUNCTIONAL DESCRIPTION OF ALGORITHMS EMPLOYED BY SUBROUTINE QKINR FOR CALCULATING INITIAL RADIATION DOSES	A-1

TABLE OF CONTENTS (CONTINUED)

Appendix		Page
B	A NUMERICAL FIT TO AN ALGORITHM WHICH COMPUTES PROMPT FISSION PRODUCT GAMMA RADIATION DOSES - - - - - - - - - - - - - -	B-1
C	FORTRAN LISTING OF SUBROUTINE WRADVN - - -	C-1
D	TABULATED COMPARISONS OF SUBROUTINE OFFCOV WITH EXACT NUMERICAL INTEGRATION -	D-1

LIST OF ILLUSTRATIONS

Figure		Page
2-1	Initial Radiation Dose vs Ground Range for a 1-KT Fission Air Burst (HOB = 53m). -	22
2-2	Initial Radiation Dose vs Ground Range for a 1-KT Fission Surface Burst. - - - - -	23
2-3	Initial Radiation Dose vs Ground Range for a 10-KT Fission Air Burst (HOB = 114m).	24
2-4	Initial Radiation Dose vs Gound Range for a 10-KT Fission Surface Burst. - - - -	25
2-5	Initial Radiation Dose vs Gound Range for a 10-KT Thermonuclear Air Burst (HOB = 114m). -	26
2-6	Neutron Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m). - - -	27
2-7	Air Secondary Gamma Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m). - - - - - - - - - - - - -	28
2-8	Fission Product Gamma Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m). - - - - - - - - - - - - -	29
2-9	Initial Radiation Dose vs Ground Range for a 10-KT Thermonuclear Surface Burst.- -	30
2-10	Initial Radiation Dose vs Ground Range for a 100-KT Fission Air Burst (HOB - 246m). -	31
2-11	Initial Radiation Dose vs Ground Range for a 100-KT Fission Surface Burst. - - - -	32
2-12	Initial Radiation Dose vs Ground Range for a 100-KT Thermonuclear Air Burst (HOB = 246m). -	33
2-13	Initial Radiation Dose vs Ground Range for a 100-KT Thermonuclear Surface Burst. -	34

LIST OF ILLUSTRATIONS (CONTINUED)

Figure		Page
2-14	Sample curve of weapon radius vs yield, for personnel. - - - - - - - - - - - - - - - - - - -	36
2-15	Increase in weapon radius by use of Optimum Height of burst. - - - - - - - - - - - - - -	39
2-16	OFFCOV - Error in COV for TAR = 0.2. - - - - -	43
2-17	OFFCOV - Error in COV for TAR = 0.4. - - - - -	44
2-18	OFFCOV - Error in COV for TAR = 0.6. - - - - -	45
2-19	OFFCOV - Error in COV for TAR = 0.8. - - - - -	46
2-20	OFFCOV - Error in COV for TAR = 1.0. - - - - -	47
2-21	OFFCOV - Error in COV for TAR = 2.0. - - - - -	48
2-22	SIRCOV - Error in COV for SIGT = 0.1. - - -	60
2-23	SIRCOV - Error in COV for SIGT = 0.2. - - -	61
2-24	SIRCOV - Error in COV for SIGT = 0.3. - - -	62
2-25	SIRCOV - Error in COV for SIGT = 0.4. - - -	63
2-26	SIRCOV - Error in COV for SIGT = 0.5. - - -	64
2-27	The Circular Coverage Function CIRCOV - - -	69
2-28	The Circular Coverage Function CIRCOV - - -	70

LIST OF TABLES

Table		Page
2-1	Comparison of weapon radii at optimum air burst altitude with those at the standard height used in TACWAR - - - - - - -	40
2-2	Comparison of SIMCN Algorithms - - - - - - -	51
2-3	Offset Circle Probabilities Distance Damage Sigma (SIGT) = 0.1. - - - -	55
2-4	Offset Circle Probabilities Distance Damage Sigma (SIGT) = 0.2. - - - -	56
2-5	Offset Circle Probabilities Distance Damage Sigma (SIGT) = 0.3. - - - -	57
2-6	Offset Circle Probabilities Distance Damage Sigma (SIGT) = 0.4. - - - -	58
2-7	Offset Circle Probabilities Distance Damage Sigma (SIGT) = 0.5. - - - -	59
2-8	Offset Circle Probabilities Error Arising From Use of Constant 0.213. SIGT = 0.4. - - - - - - - - - - - - -	65
2-9	Offset Circle Probabilities Error Arising From Use of Constant 0.213. SIGT = 0.5. - - - - - - - - - - - - -	66
2-10	The Circular Coverage Function Numerical Integration - - - - - - - - - - - -	71
A-1	Values of Exponents and Coefficients Used in Calculating Neutron and Air-Secondary Gamma Ray Doses in Subroutine QKINR - - - -	A-2
D-1 thru D-33	OFFCOV - - - - - - - - - - - - - - - - - -	D-2 thru D-34

SECTION I

INTRODUCTION AND SUMMARY

This report documents the results of investigation of the nuclear weapons effects module of TACWAR, a theater-level computerized warfare simulation code*, with the purpose of verifying the accuracy of its data. Periodic checks of nuclear effects data in wargaming codes are desirable to ensure that errors do not cause discrepancies in the intercomparison of various models and to preclude the propagation of erroneous results or the influencing of decisions affecting force posture or hardware procurement based on faulty nuclear effects data.

This report is not intended to stand apart from the extensive body of TACWAR documentation. It assumes reader familiarity with the capabilities and content of the TACWAR code. A complete description of this code and its subroutines is contained in the TACWAR documentation[1-7]**.

This study has investigated the accuracy of (1) the nuclear weapon effects information contained in the damage assessment subroutines, (2) selected algorithms to calculate target coverage, and (3) logic in the subroutines. The effort has not addressed escalation criteria, priority criteria in nuclear targeting, or the logic of weapon assignment algorithms.

---

* TACWAR was developed by the Institute for Defense Analyses.

** References are listed immediately following Section II.

The following subroutines were scrutinized in this project:

- NUC6. The master program for nuclear damage assessment.
- DAMEVL. The main subroutine which performs damage assessment calculations with the aid of nine called subroutines.
- DOSLIM. Sets the limiting nuclear radiation doses to define "pools" into which personnel are placed, depending on the dose they receive.
- FN. Calculates the range to given initial nuclear radiation doses, the boundaries of the pools established by DOSLIM.
- PREFN. A utility subroutine which acts as an interface between FN and QKINR, and calls QKINR to calculate the initial radiation dose at each of 23 slant ranges.
- QKINR. Calculates the dose due to neutrons, air-secondary gamma rays and fission-product gamma rays at each of the ranges specified by PREFN.
- WRAD. Calculates the weapon radius against personnel in specified shelter postures, exposed to nuclear air bursts or surface bursts of specified yields.
- WRADVN. Implements the Physical Vulnerability System[8] to calculate the weapon radius against material targets given the yield and burst height of the weapon and the vulnerability number of the target.
- OFFCOV. Calculates the expected coverage of a circular target of uniform value by a weapon delivered at an offset aimpoint.
- SIMCN. Calculates the cumulative circular normal distribution function.

The following subroutines were scrutinized in this project:

- NUC6. The master program for nuclear damage assessment.
- DAMEVL. The main subroutine which performs damage assessment calculations with the aid of nine called subroutines.
- DOSLIM. Sets the limiting nuclear radiation doses to define "pools" into which personnel are placed, depending on the dose they receive.
- FN. Calculates the range to given initial nuclear radiation doses, the boundaries of the pools established by DOSLIM.
- PREFN. A utility subroutine which acts as an interface between FN and QKINR, and calls QKINR to calculate the initial radiation dose at each of 23 slant ranges.
- QKINR. Calculates the dose due to neutrons, air-secondary gamma rays and fission-product gamma rays at each of the ranges specified by PREFN.
- WRAD. Calculates the weapon radius against personnel in specified shelter postures, exposed to nuclear air bursts or surface bursts of specified yields.
- WRADVN. Implements the Physical Vulnerability System[8] to calculate the weapon radius against material targets given the yield and burst height of the weapon and the vulnerability number of the target.
- OFFCOV. Calculates the expected coverage of a circular target of uniform value by a weapon delivered at an offset aimpoint.
- SIMCN. Calculates the cumulative circular normal distribution function.

- SIRCOV. Calculates the expected coverage of a circular Gaussian-distributed target by a weapon delivered at an offset aimpoint.

- CIRCOV. Calculates a Gaussian function integrated over an offset circle. It is equivalent to either the probability of an offset aimed weapon impacting a circular target, or that an offset aimed weapon having a specified radius will hit a point target.

Detailed descriptions of the results of investigation of these subroutines are presented in sections 2-1 to 2-10 of this report. A summary of those results is presented below*.

1-1 DAMEVL

The portion of DAMEVL which assesses damage to personnel contains a call to WRADVN with a vulnerability number (VN) for personnel. No source for such a VN could be identified. An alternative method using subroutine WRAD would require classified input data and a rather subtle program change to be operative. This alternative method should be added to the program.

In addition, weapon radii in radiation-dominated portions of WRAD, which are based on a 450-rad lethality criterion, when compared with the results of FN, are always selected over those for higher radiation "states." As a result, no targeted personnel would ever undergo transitions to the higher states.

Finally, DAMEVL does not assess damage to military personnel at surface to surface missile sites or at supply depots.

1-2 PREFN

Opportunity for user input of weapon type, fission fraction and air density has not been provided. These have

---

* Note that not all subroutines listed in Section II are mentioned in this summary.

been fixed at fission, one-half and 1.1 x 10^{-3} gm-cm^{-3}, respectively. Height of burst can be either 174 ft/$kt^{\frac{1}{3}}$ or zero. Aside from contributing to unrealistic input data, this inflexibility could result in errors of 20 to 50 percent in dose at a given slant range. An error of a factor of 100 exists in the height of burst argument for calculating the slant range, which will cause significant errors in some ground ranges.

1-3 QKINR

Significant divergences occur between TACWAR calculations and other newly calculated radiation levels at given slant ranges. A neutron multicollision term (x 2) has been introduced into the calculations but apparently not into the shielding or biological response data. This point is the subject of further investigation. The weapon types, "fission," "intermediate" and thermonuclear" are not sufficiently broad for force posture studies requiring the capability to assess the possible impact of enhanced radiation weapons.

1-4 WRAD

Only nuclear radiation and air blast effects are now included in this subroutine. Thermal radiation is the dominant lethal effect on unwarned, exposed personnel, over a significant range of yields from nuclear surface bursts. This effect could be incorporated in the subroutine. Yield interval breakpoints, coefficients and exponents have not been verified.

1-5 WRADVN

This subroutine now permits use of only two scaled heights of burst, zero and 174 feet. Consequently, weapon radii against soft targets (i.e., QVN $\leq$ 10, PVN $\leq$ 15) are reduced up to 40 percent because optiumum height of burst cannot be utilized.

1-6 OFFCOV

The algorithm uses dimensions normalized in units of the weapon radius. However, prior to this normalization a lower limit to the calculation is established by setting the coverage at zero if the weapon radius (WR) (unnormalized--any units) is less than 0.001. WR should first be normalized in units of target radius.

In the target coverage interval between 10 and 90 percent, the accuracy of the algorithm frequently deviates by as much as 20-30 percent from the true value. In one extreme case, a numerically integrated value of 0.100 is calculated by the algorithm as 0.186, an 86 percent error. More extreme values of coverage contain larger (percentage) errors.

1-7 SIMCN

The algorithm used to replace the exact integration is sufficiently accurate in all relevant regimes of the independent variable. However, another algorithm, somewhat simpler to implement and slightly more accurate, is suggested for use. Numerous documentation errors have been noted and tabulated.

1-8 SIRCOV

This algorithm also normalizes the variables in units of (adjusted) weapon radius. However, prior to normalization, the coverage is set at zero for values of the weapon radius (in any units) less than 0.1. A method of normalizing this variable, making it dimensionless, is suggested. Several documentation errors have been noted and tabulated.

1-9 CIRCOV

The selected algorithm is accurately implemented in the Fortran, but has discontinuities at two points in variable-space, and other inaccuracies which produce 10-percent errors in predicted coverage when the coverage is in the range 5 percent to 95 percent. Outside this region the errors rapidly increase to, for example, a factor of two at 1 percent coverage.

1-10 RECOMMENDATIONS

Based upon analysis of the TACWAR nuclear effects data and subroutines, the following changes or additions to the subroutines in NUC6 are recommended:

a. Provide an algorithm for calculating dose from enhanced radiation weapons.

b. Allow only one option, that employing subroutine WRAD, to calculate weapon radius for personnel damage, and set WRAD = 0 over yield ranges where it is radiation-dominated.

c. Update the dose calculation from initial nuclear radiation to conform to more recent, more accurate calculations.

d. Include a thermal option for unwarned personnel exposed to a surface burst.

e. Include personnel damage assessment in surface to surface missile sites and supply depots.

f. Implement various normalizations (OFFCOV, SIRCOV), an algorithm change (SIMCN), and correct the numerical error (SIRCOV) in the several circular coverage subroutines.

SECTION II

DETAILED DISCUSSION OF SUBROUTINES

2-1 DAMEVL

This is a multipurpose subroutine which has among its functions the evaluation of damage to targets including military and civilian personnel. As presently coded, DAMEVL calculates personnel damage in the following situations:

Situation	Military Personnel	Civilian Personnel
Battlefield	x	x
Airbases	x	x
SSM Sites*		x
Supply Depots*		x

The assessment should be extended to include military personnel at supply depots and at surface to surface missile sites. Conversations with field-experienced army officers as well as with members of the analytical community have confirmed our belief that trained military personnel are important to successful operation of both of these facilities.

Radii of effects against personnel from two different calculations are compared: (1) calculations using Part III of reference 8, and (2) subroutine FN. These two calculations are referred to as methods (1) and (2) below.

---

* Comparison of WRAD with FN is not carried out in the current version of TACWAR in assessing civilian personnel damage at SSM sites and supply depots.

Method (1) involves calculation of weapon radius as in reference 8 by use of a personnel vulnerability number (VN). No VN is provided, nor is any acceptable VN known to exist. There is another option, which can be activated by a change in coding. This option relies on power-law fits to the curves of weapon radius against personnel in Part III of reference 8. For a given shelter posture, weapon radius against personnel depends on yield and height of burst. At low yields nuclear radiation is the dominant kill mechanism and at higher yields air blast becomes dominant. Subroutine WRAD implements an algorithm which approximates the weapon radius vs. yield curves and calculates weapon radii against personnel in given shelter postures subjected to weapons of specified yields. This will be discussed in more detail in Section 2-6.

Method (2) uses the initial radiat . algorithms to determine radii to the limiting dose levels of higher radiation "states" or "pools" (see discussion under subroutine DOSLIM). Subroutines FN, PREFN and QKINR are exercised to determine the radii from surface ground zero to given initial radiation doses at the boundaries of the various "states."

Weapon radii calculated by methods (1) and (2) are compared. The larger radius is selected for calculation of target coverage. This means that transitions into higher radiation states can never occur because for low yield weapons the radius to 450 rad will be larger than that for transitions to higher radiation states, and for higher yield weapons blast or thermal radii will dominate. It therefore seems appropriate to set weapon radius to

zero in the yield intervals of WRAD when the weapon radius is dominated by nuclear radiation.

2-2 DOSLIM

This subroutine establishes upper and lower boundaries of radiation states. For example, in the TACWAR print-outs examined in this effort the following dose levels were selected as defining radiation states.

State		1		2		3		4		5	
Dose, rad	0		50		450		3000		8000		≥20000

TACWAR logic allows for statistical fluctuations by placing all personnel in the center of the dose range defining each pool or state. Thus, exposure to 25 rad will result in transition from state 1 to state 2, 200 rad will cause a transition from state 2 to state 3, etc.

2-3 FN

This subroutine scans the array of doses calculated by QKINR as directed by PREFN, and finds the horizontal range at which the dose is equal to the input value, which is one of the boundaries of the radiation states furnished by DOSLIM, or, in the case of civilian personnel, the casualty or fatality dose (250 or 450 rad, respectively). Neutron and gamma transmission factors are first applied, according to protection category date for the personnel being considered.

FN is called only for military and civilian targets at airbases and on the battlefield.

2-4 PREFN

This subroutine is used as a controlling subroutine between FN (where range to a given dose level is calculated) and QKINR (where the dose level at a given range is computed). PREFN receives input parameters from DAMEVL and calls QKINR at each of 23 horizontal ranges and input burst heights for every weapon.

PREFN is used to provide to QKINR certain input data which set the parameters for dose calculations. These parameters appear to be frozen at single values, without presenting any options to the user for inserting weapon-specific or situation-specific values. Some inputs are in fact rather unrealistic. For example, only fission weapons and 50-percent fission fractions are presently used. Only two heights of burst, zero or 174 $ft/kt^{1/3}$, are allowed. Atmospheric density is set at 1.1×10^{-3} gm/cm^3. We recommend that weapon parameters be specified as part of the input data base and that user options be added for air density as well.

PREFN also furnishes input on the neutron multicollision factor. This factor is presently set at 2. The effect is that all free field neutron doses are doubled for calculations of biological response. It appears that the factor is inserted correctly in defining the in-body radiation environment, but that it must also be applied to biological response criteria which are, so far as can be, based on free-field doses.

One of the functions of PREFN is to calculate slant range to the target and this appears to contain an error. As described in the documentation IHOB is either 1 (airburst) or 0 (surface burst), and if 1, the height of burst is set at 1.74, in units of one hundred feet. Thus when calculating slant range it appears that a factor of 100 should multiply the term HBR in order to produce a correct value of slant range to the target.

2-5 QKINR

This subroutine, which calculates the initial radiation environment from nuclear air and surface bursts, was verified against the source material[9] on which it was based, and was also compared with results of more recent work[10] in the field of radiation transport models.

Calculation of dose from neutrons and air-secondary gamma rays is a relatively straightforward process involving spherical divergance and exponentials in slant range, normalized to fit available empirical data. A rather simple height-of-burst correction is also employed. Examples of expressions used in the QKINR algorithm are contained in Appendix A.

The algorithms used in QKINR for the fission product contribution were developed as a fast-running implementation of the method of French and Mooney[9]. They are fully described in a working paper provided by the Institute for Defense Analyses and reproduced as Appendix B. A functional description of the algorithms is also given in Appendix A.

Two routes were followed in verifying initial nuclear radiation environments of TACWAR:

- Results of independent ("offline") use of the simplified algorithms were compared with the model on which they are based, and on more recent calculations.

- QKINR as received from CCTC was exercised ("online") to determine nuclear environments directly.

Figures 2-1 through 2-13 contain results of off-line calculation of the algorithms described in Appendix B and the CCTC listing. These calculations were programmed and executed on a microcomputer. The results have been plotted as total initial radiation dose as a function of ground (horizontal) range for two types of warhead design, fission and thermonuclear. Calculations were performed for surface bursts and air bursts at yields of 1*, 10 and 100 KT. Comparison standards were selected as follows. At all three yields, data from reference 9 labeled "French and Mooney" on the figures are shown. For 10 and 100 KT, more recent calculations[10] were obtained and added to the comparison base, labeled "Gritzner et al." In addition, the 10-KT thermonuclear air burst was singled out for more detailed checks of the initial radiation components, i.e., neutrons, air-secondary gamma rays, and fission-product gamma rays, against available references. Data were also obtained, for general interest, from reference 11.

The degree to which TACWAR calculations agree with comparison standards may be observed by examining Figures 2-1 through 2-13. In general, TACWAR calculations of total dose are in fairly good agreement with the data of French and Mooney on which they were based. This seems to be due to balancing errors of the dose components. TACWAR is high by a factor of two in neutron dose, but low with respect to the fission-product gamma dose. The total dose has been

---

* In the interest of realism, only the fission case was run at 1 KT.

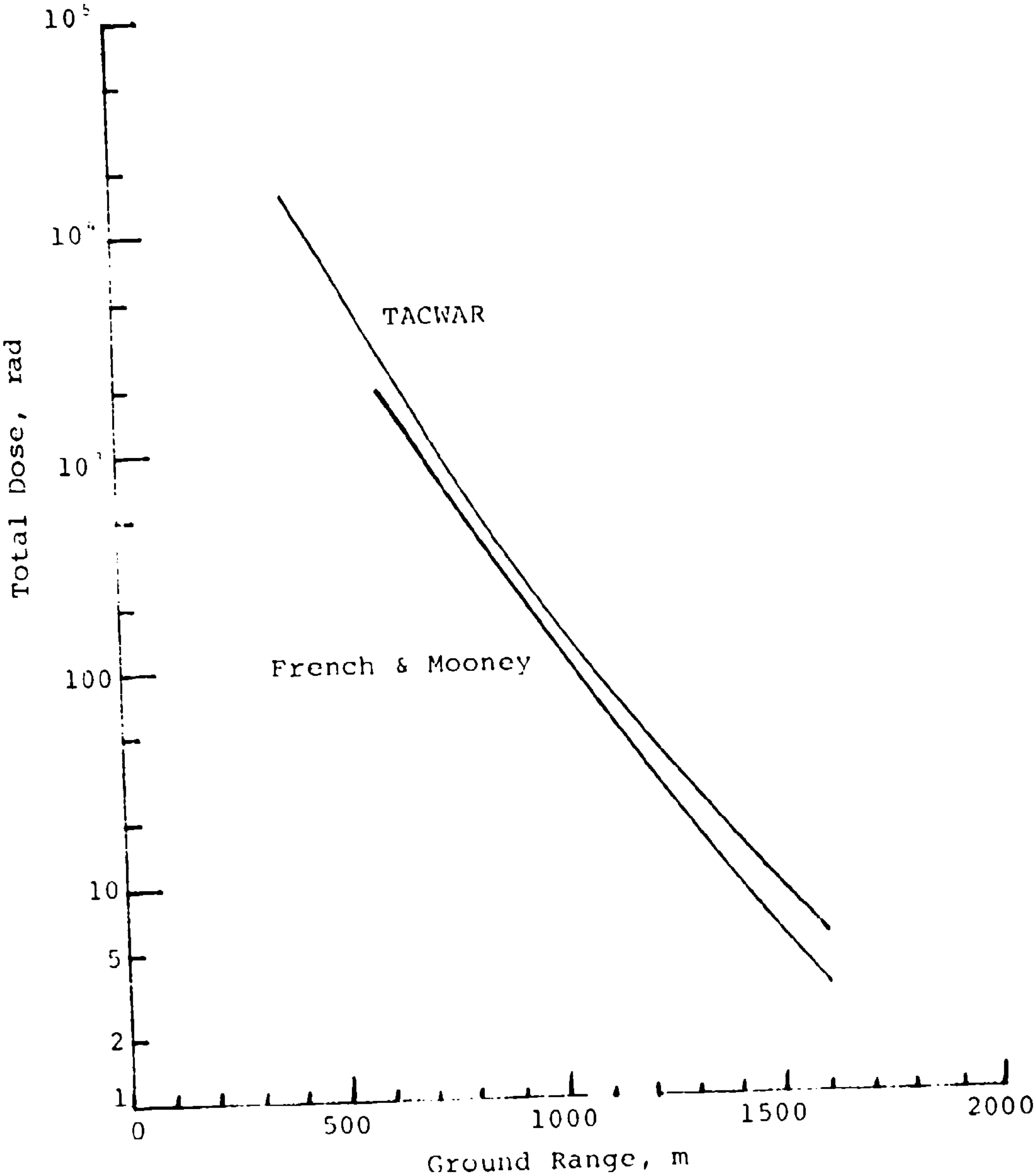

Figure 2-1 Initial Radiation Dose vs Ground Range for a 1-KT Fission Air Burst (HOB = 53m).

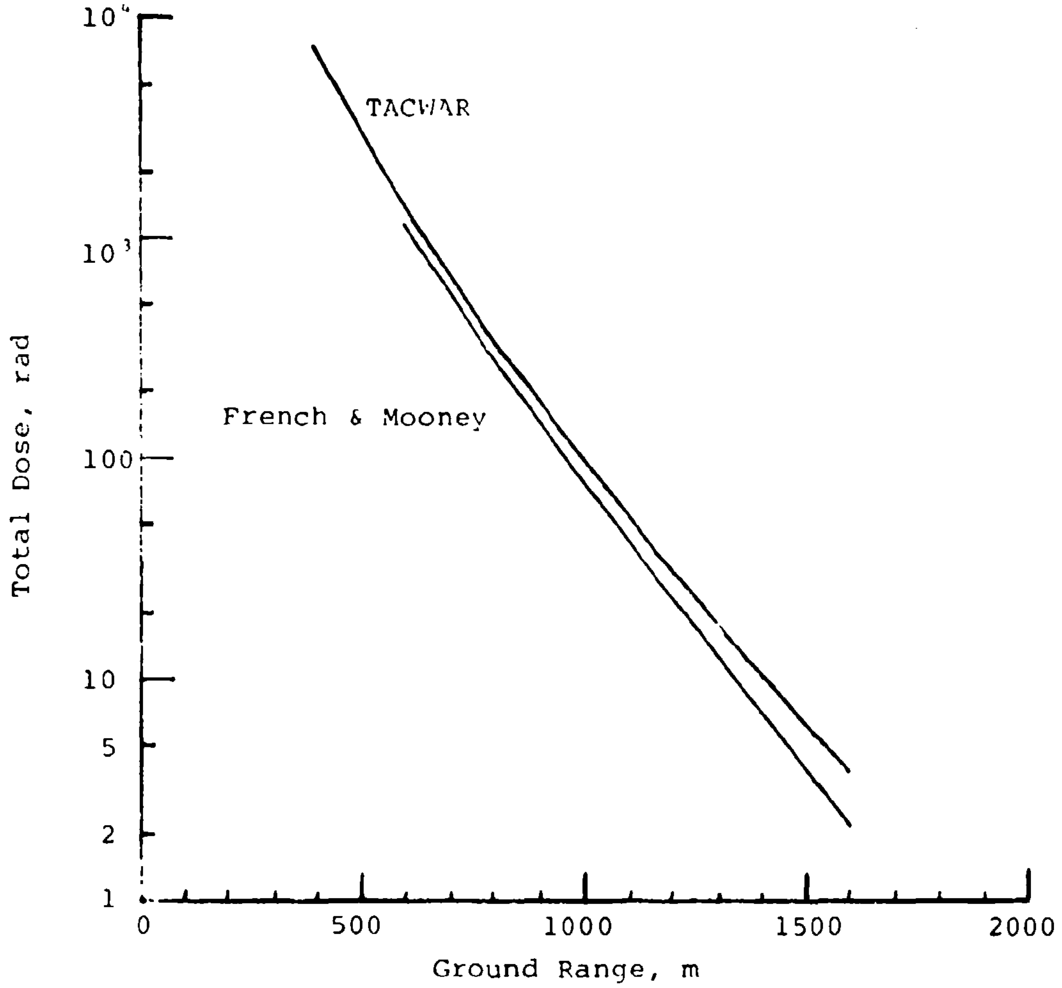

Figure 2-2 Initial Radiation Dose vs Ground Range for a 1-KT Fission Surface Burst.

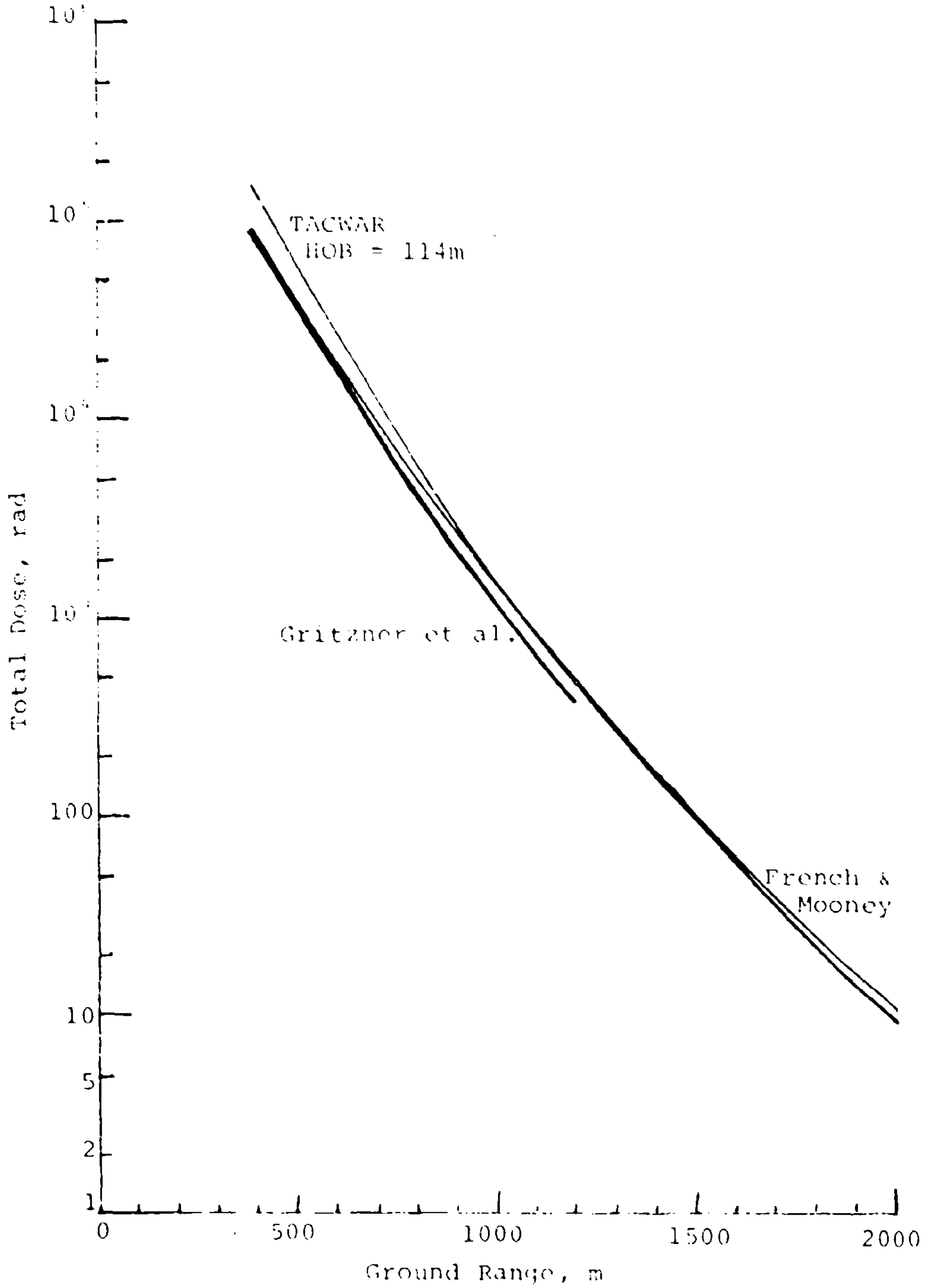

Figure 2-4 Initial Radiation Dose vs Ground Range for a 10-KT Fission Air Burst (HOB = 114m).

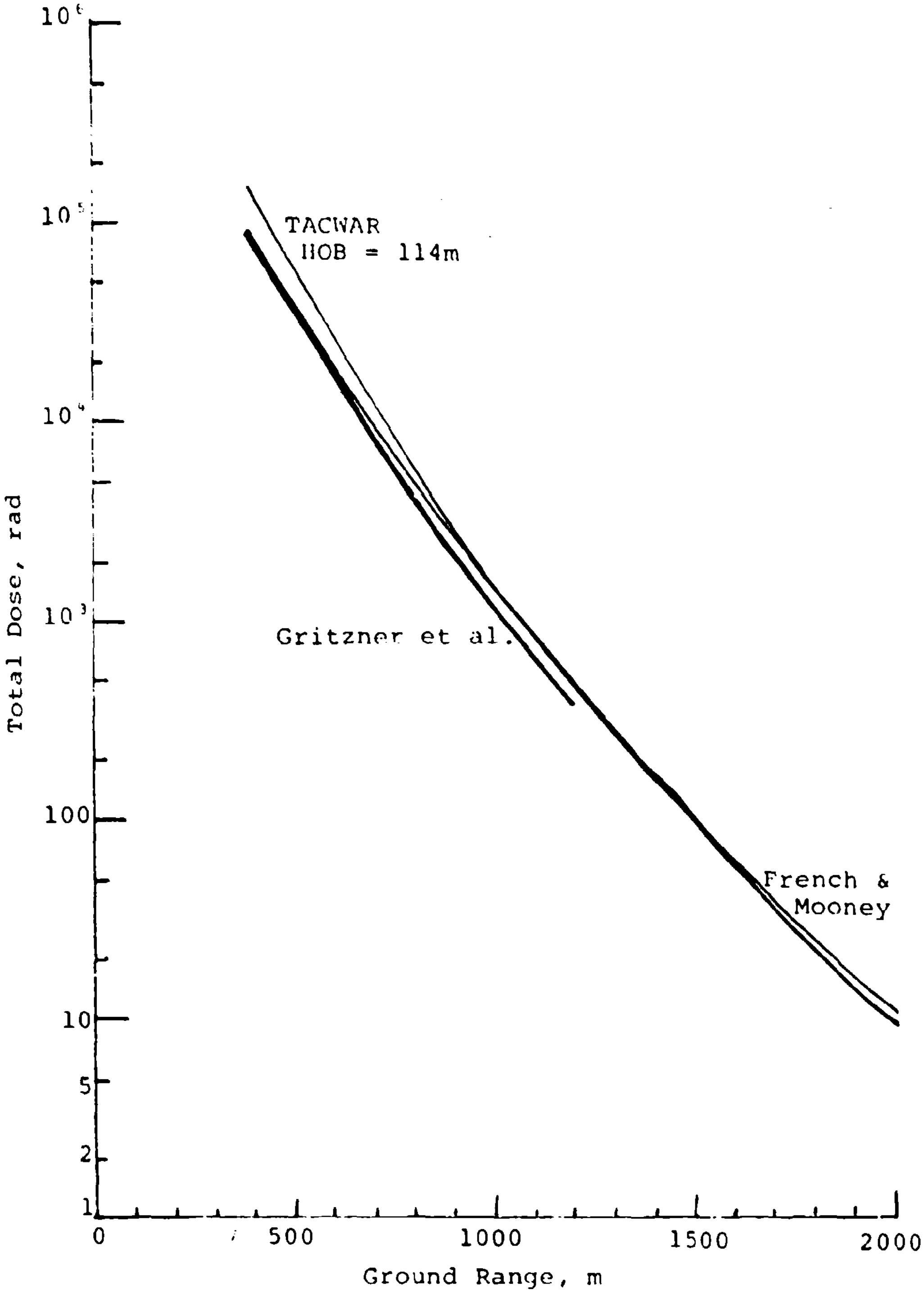

Figure 2-4. Initial Radiation Dose vs Ground Range for a 10-KT Fission Air Burst (HOB = 114m).

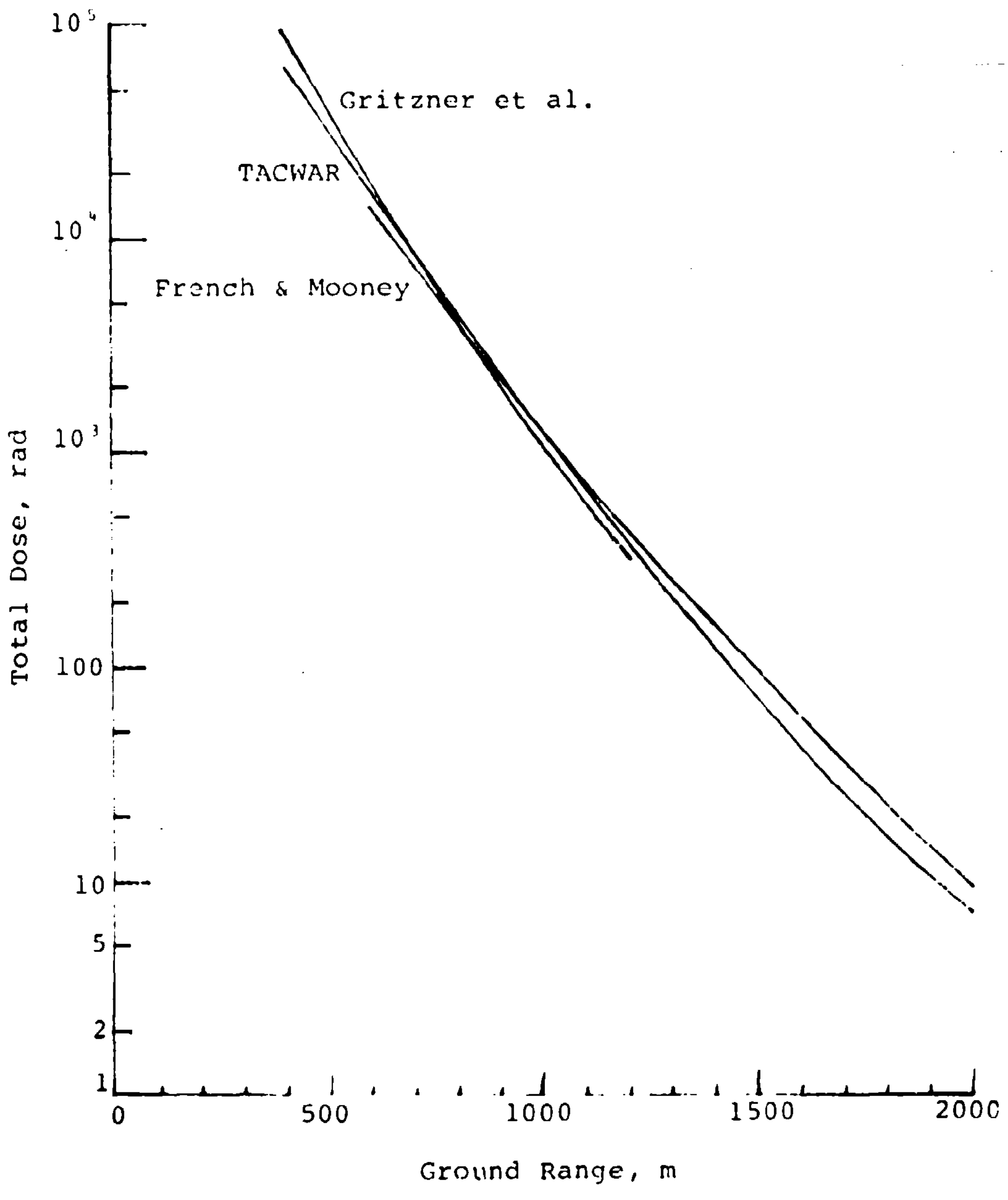

Figure 2-4 Initial Padiation Dose vs Ground Range for a 10-KT Fission Surface Burst.

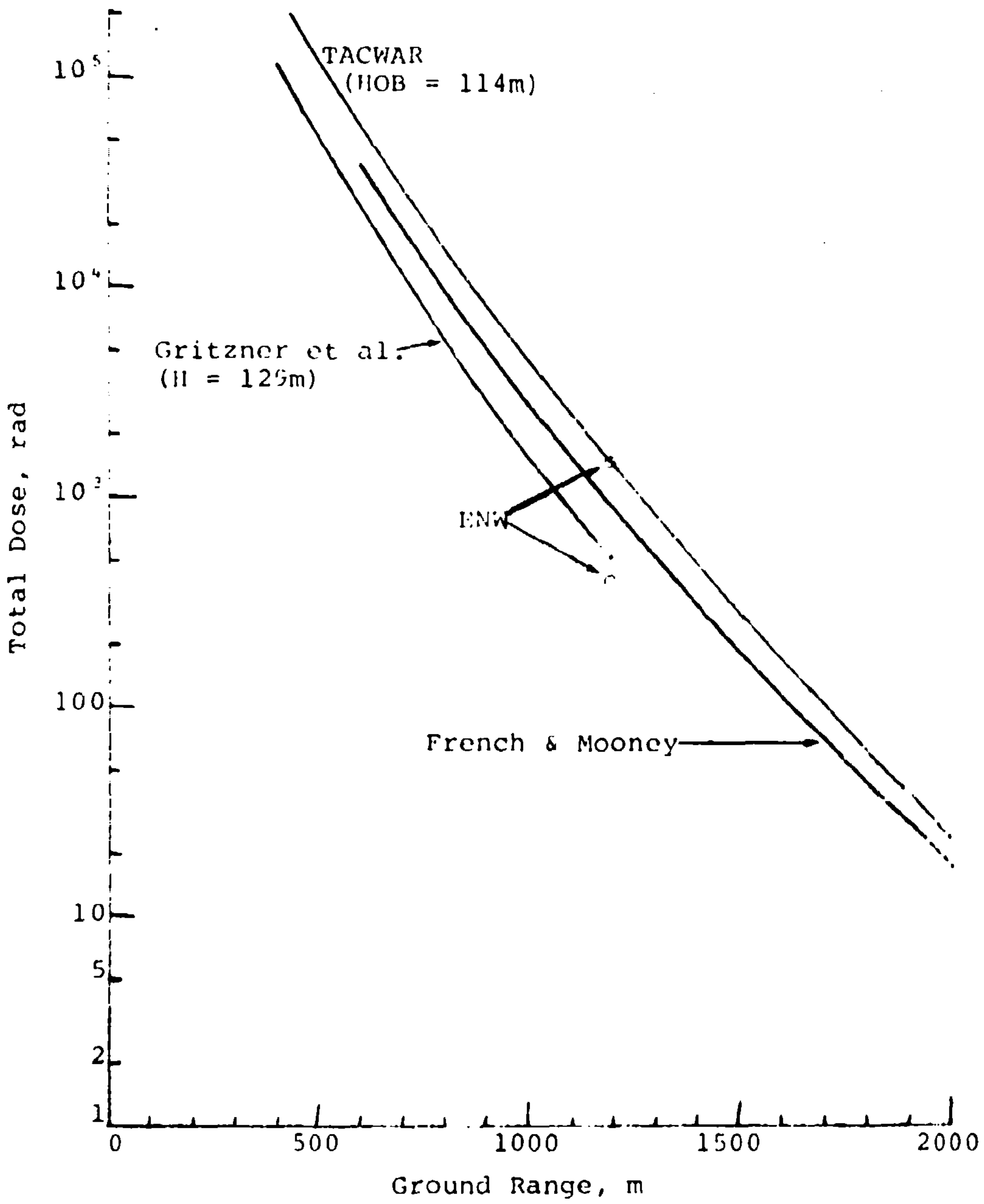

Figure 2-5 Initial Radiation Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m).

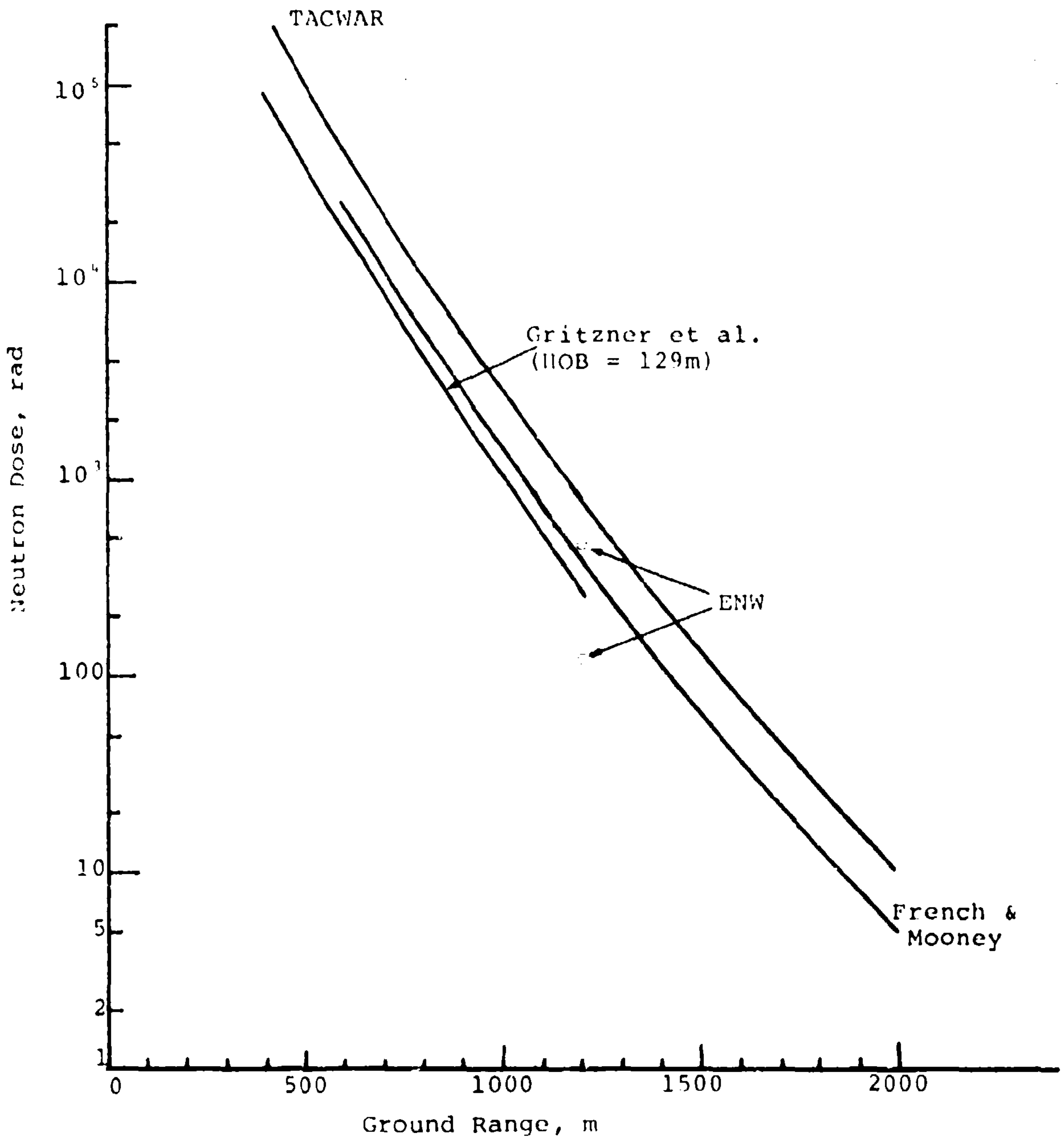

Figure 2-6 Neutron Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m).

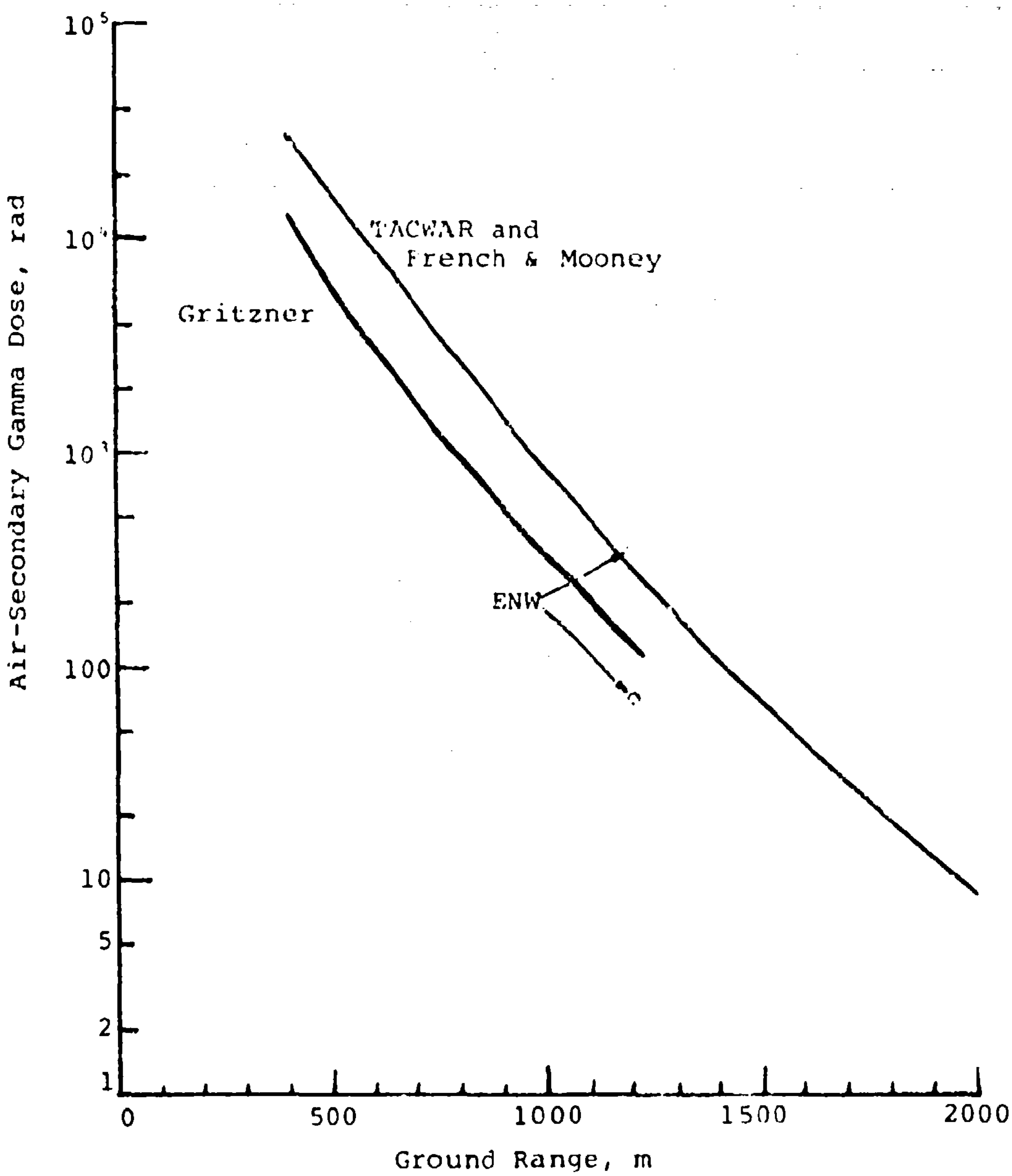

Figure 2-7 Air-Secondary Gamma Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m).

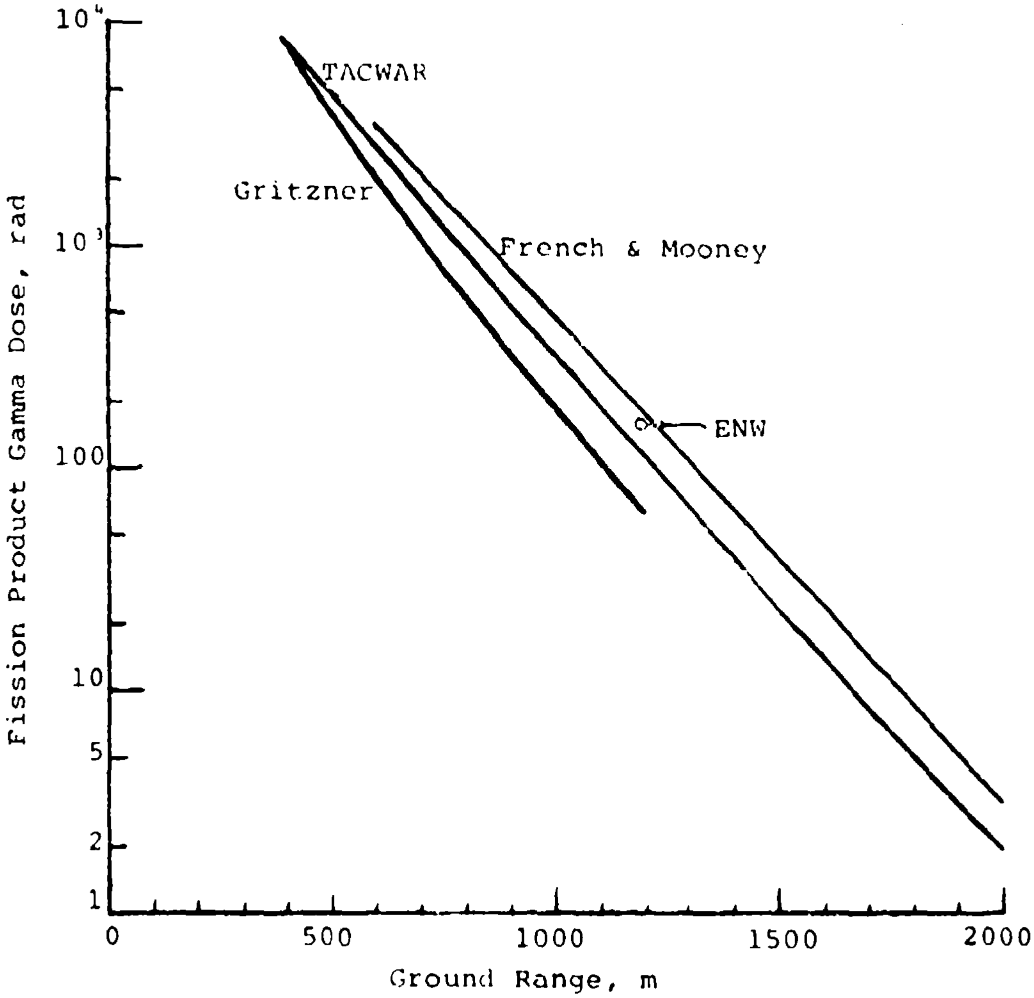

Figure 2-8 Fission Product Gamma Dose vs Ground Range for a 10-KT Thermonuclear Air Burst (HOB = 114m).

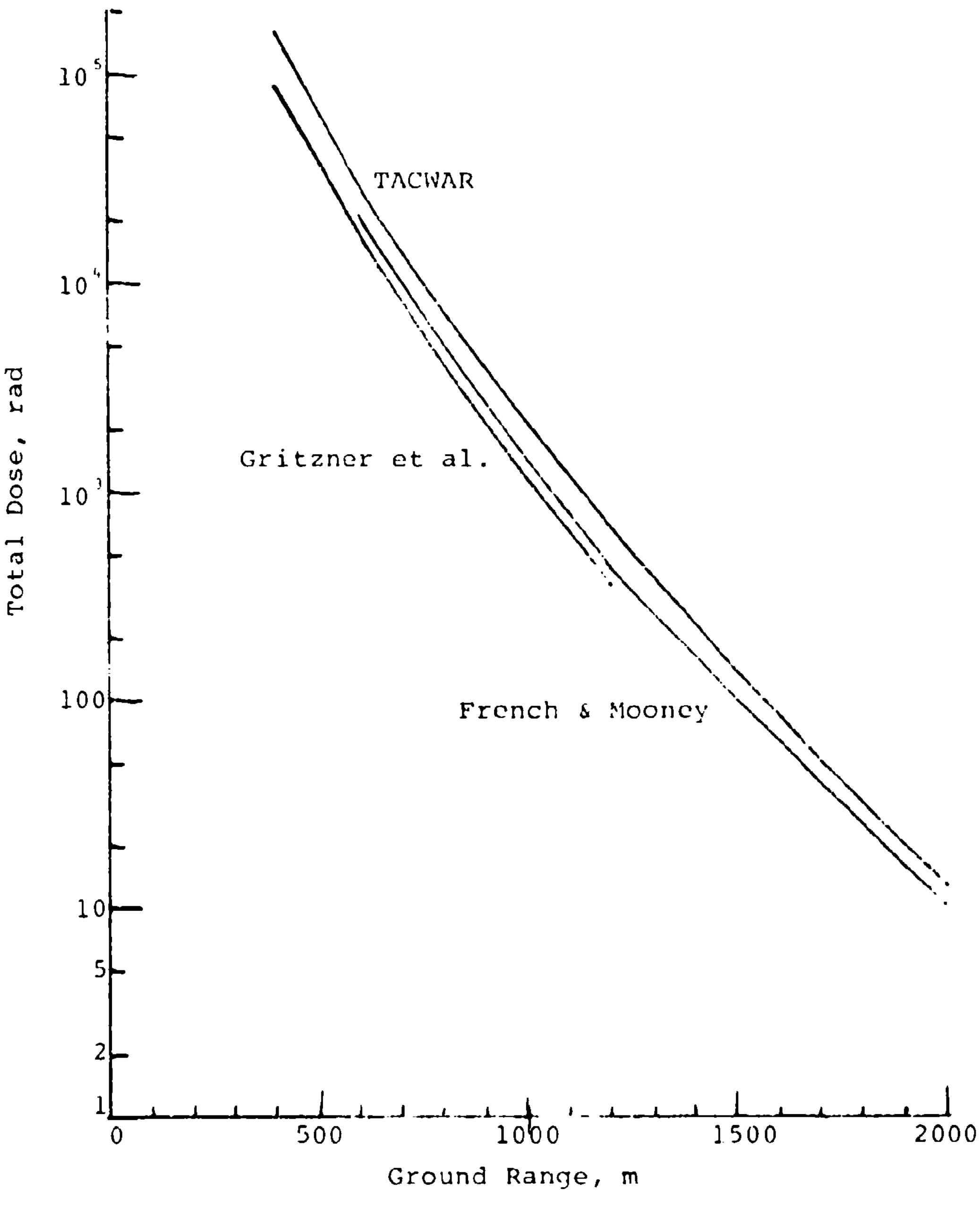

Figure 2-9 Initial Radiation Dose vs Ground Range for a 10-KT Thermonuclear Surface Burst.

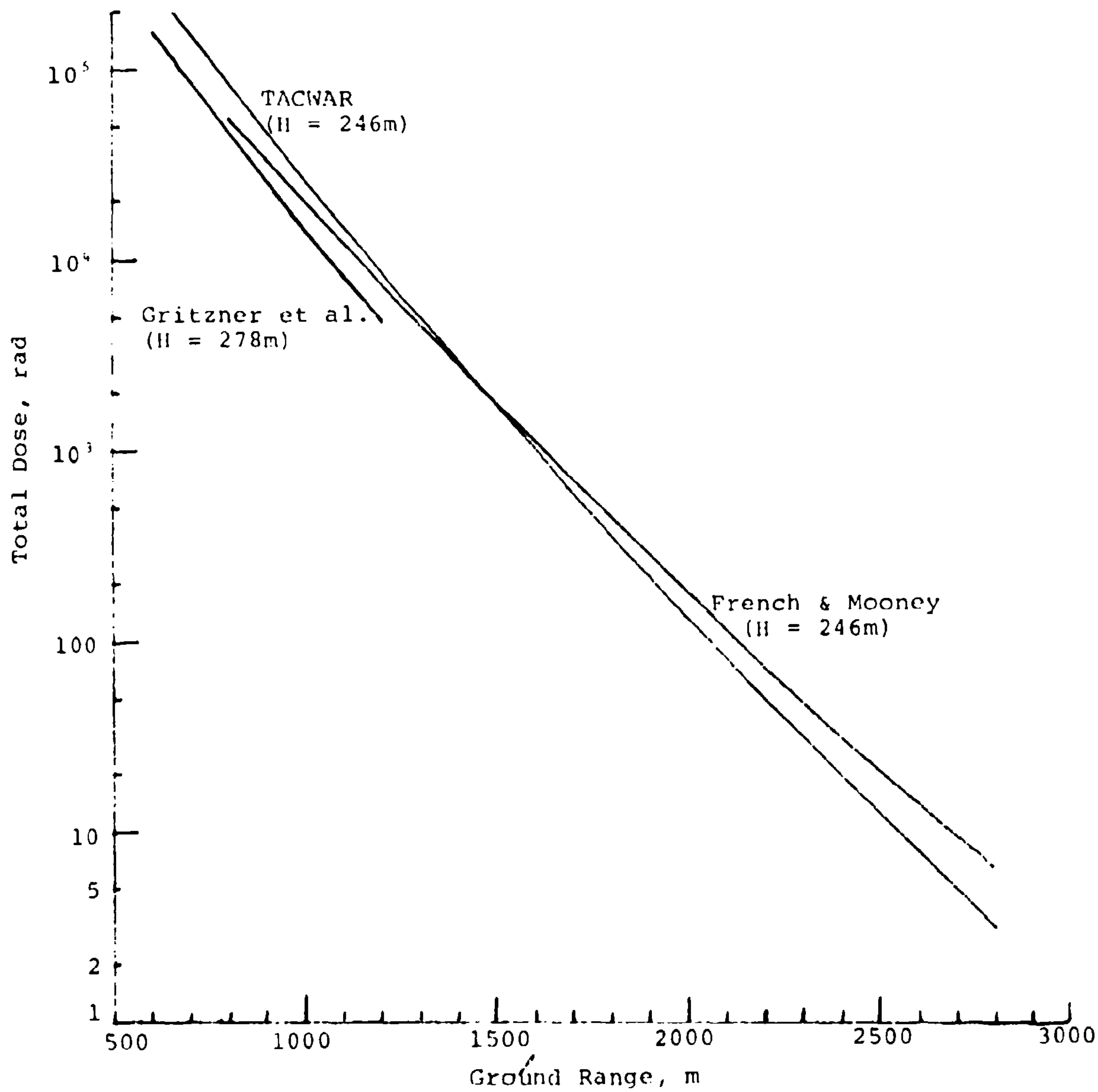

Figure 2-10 Initial Radiation Dose vs Ground Range for a 100-KT Fission Air Burst (HOB = 246m).

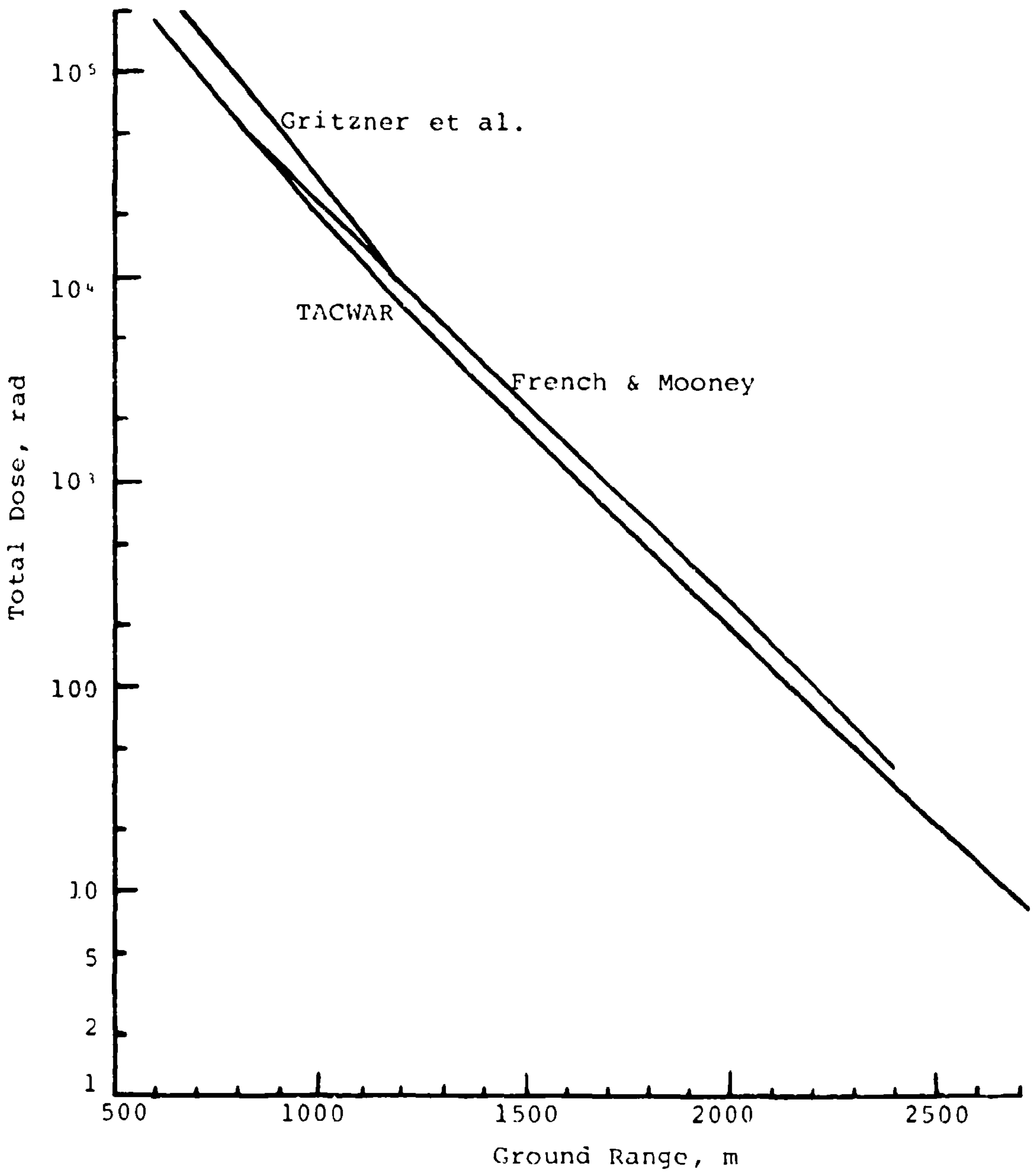

Figure 2-11 Initial Radiation Dose vs Ground Range for a 100-KT Fission Surface Burst.

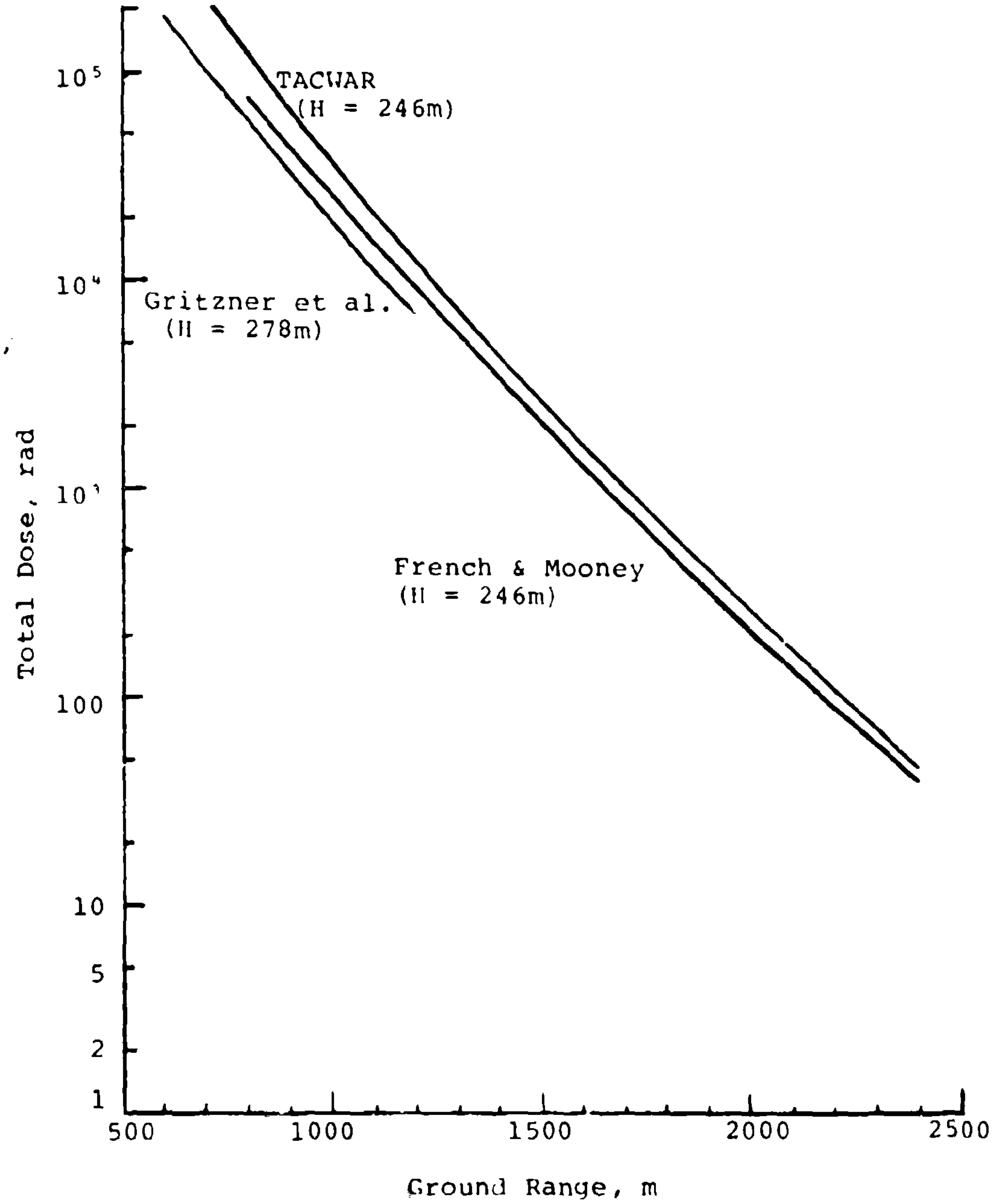

Figure 2-1. Initial Radiation Dose vs Ground Range for a 100-KT Thermonuclear Air Burst (HOB = 246m).

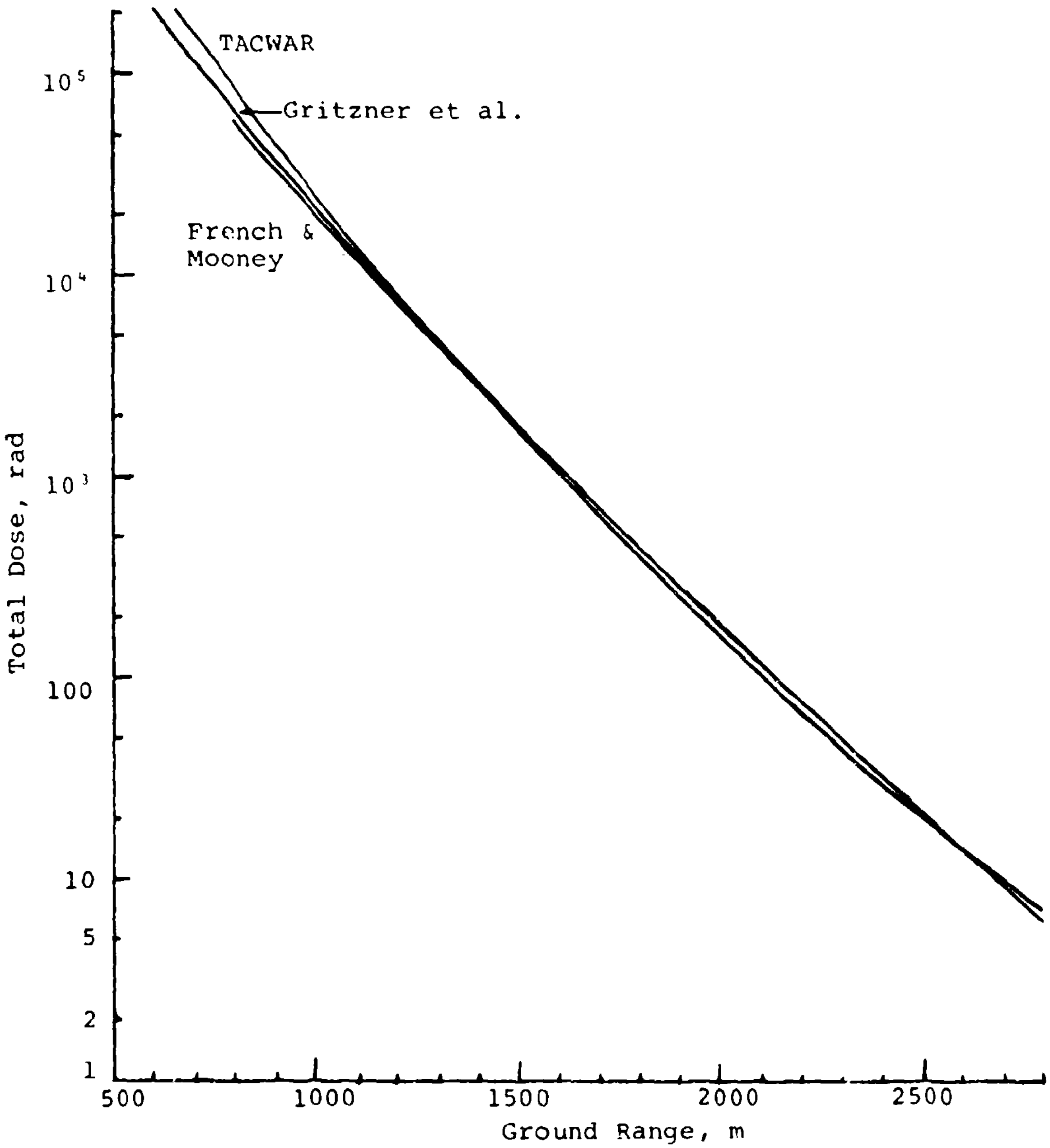

Figure 2-13 Initial Radiation Dose vs Ground Range for a 100-KT Thermonuclear Surface Burst.

resolved into its component parts (i.e., neutrons, air-secondary gammas and fission-product gammas) for illustrative purposes in Figures 2-6 to 2-8.

Online calculations of these cases were performed using QKINR on the S^3 Univac 1108, and were found to be identical with the offline calculations.

None of the existing weapon types in QKINR addresses the enhanced radiation (ER) warhead. The neutron spectrum of the ER is sufficiently different from that of fission or thermonuclear weapons that a separate weapon type should be included in QKINR. Use of ER warheads is being studied at many levels in the DOD, and it would appear to be prudent to include an ER weapon in the calculations to allow inclusion of the ER within the scope of TACWAR studies.

2-6 WRAD

This subroutine calculates the weapon radius due to blast (or radiation) against personnel located in one of eight protection categories. Input parameters consist of coefficients and exponents C and A in the expression

$$WRP = \frac{C}{3.281} W^A$$

Where WRP is the weapon radius in meters and W the yield input. C (in feet) and A are directly obtainable for various protection categories as defined in reference 8. They are not currently available in unclassified form, hence the data array for these inputs is set to all zeros. The curves of weapon radius vs. yield in reference 8 are divided into portions of nuclear radiation-dominance and blast-dominance, each approximated by a straight line segment, with changes in slope occuring at yields where radiation becomes dominant over blast. The yield at which this occurs is called the "breakpoint." Thus WRAD uses an algorithm which specifies the broken curve illustrated in Figure 2-14 by the constants C and A for each region and the yield breakpoint separating the regions of validity.

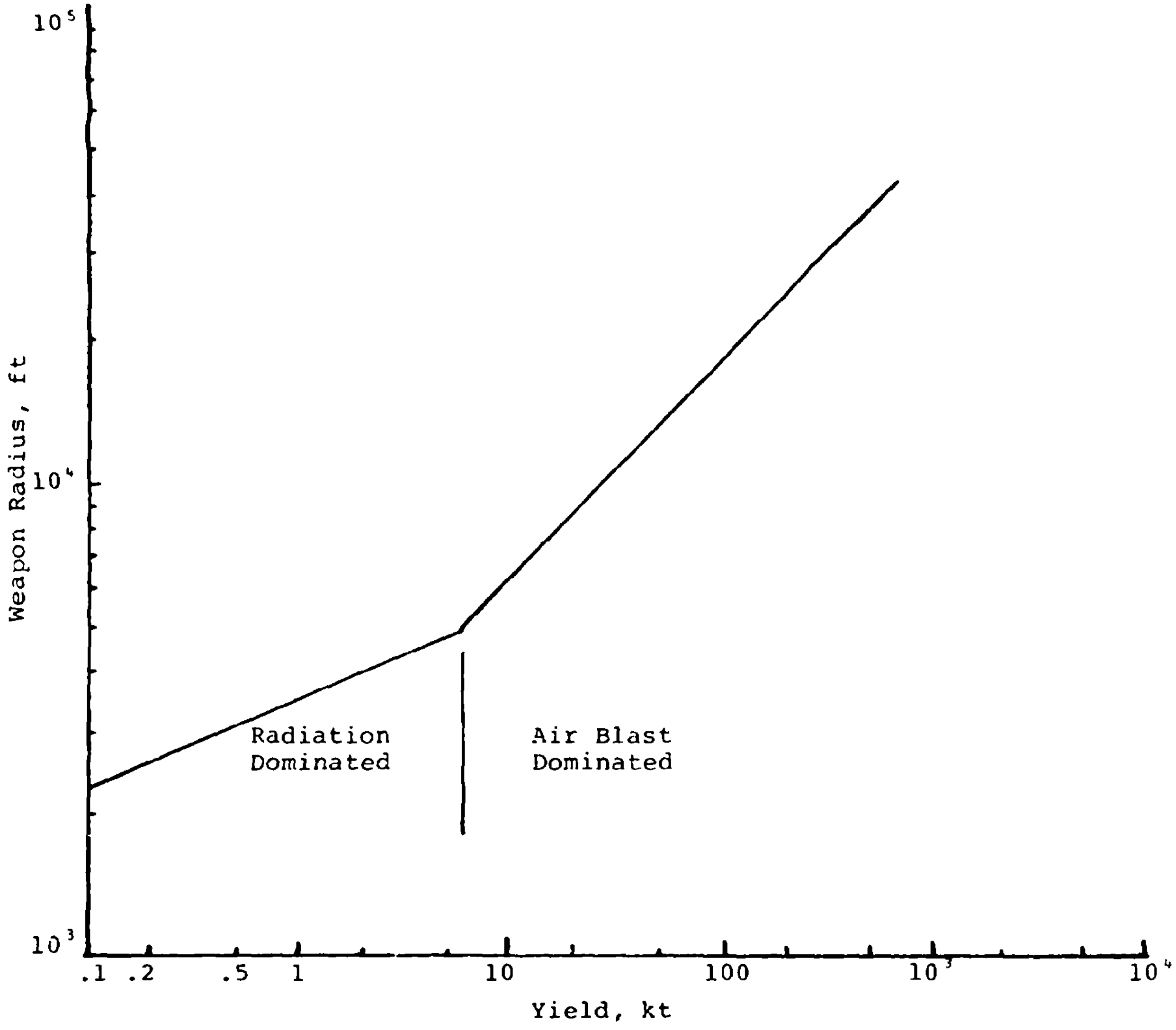

Figure 2-14. Sample curve of weapon radius vs yield, for personnel.

There is no allowance for thermal effects upon unwarned personnel in the open. Comparison of weapon radii due to thermal effects of both "fatal" and "incapacitating" intensity shows that thermal fatality radii dominate blast fatality radii for nuclear surface bursts at the higher end of the abscissa. This can be accounted for, if desired, by adding or adjusting the exponents and coefficients for the protection category for exposed personnel.

Preliminary investigation indicates that one breakpoint with two coefficients and exponents can adequately fit the curves in reference 8. However, the actual values used remain to be fully verified. TACWAR has the capability of implementing a curve-fitting procedure using multiple breakpoints.

2-7 WRADVN

This subroutine is used to calculate the weapon radius due to nuclear airblast. Methodology of the Physical Vulnerability System[8] is employed. Input quantities are the yield, height of burst and vulnerability number. Output quantities are the weapon radius and damage "sigma" as defined in reference 12. Detailed investigation of the Fortran listing for WRADVN reveals that methodology of reference 8 was accurately followed. Appendix C contains the Fortran listing as it appears in TACWAR, with explanatory comments.

TACWAR allows only two values for the scaled height of burst, zero and 174 feet. In the case of a surface burst the table of weapon radii, TABWR, contains entries from Table I-16 of reference 8 for P-type targets and from Table I-18 for Q-type targets. For air bursts the height of burst (HOB) inferred by interpolating weapon radii was 174 feet, in agreement with subroutine DAMEVL which sets HOB at 174 feet for all air bursts.

The vulnerability number IVN is unpacked by the usual methods. Thus a VN of 14Q7 (which appears as 1427 in TACWAR) is resolved into its component parts: VN, the hardness; IPQ, the target type (1 = P, 2 = Q) and the yield-adjustment factor XK (or K in the usual nomenclature of reference 8). The "damage sigma" (WSIG) is set at 0.2 for P-targets and at 0.3 for Q-targets. Next the VN is adjusted for yield in accord with the methodology of reference 8. The resulting VN is used as the entering argument for looking up the scaled weapon radius in array TABWR. Logarithmic interpolation is employed to correct for fractional values of the adjusted VN. Finally, the weapon radius is scaled up (or down) to the input value of weapon yield.

Restricting all nuclear airbursts to a fixed scaled altitude of 174 ft/kt$^{1/3}$ has the effect of reducing the effectiveness of weapons against soft targets. Increases of up to 40 percent in WR compared to the value of WR at 174 ft/kt$^{1/3}$ can be achieved against soft targets by increasing the HOB to its optimum value. Figure 2-15 shows, for P type and Q type targets, respectively, the ratio of weapon radius at optimum HOB to that at 174 ft/kt$^{1/3}$ (WR_{op}/WR_{174}) as a function of the vulnerability number (VN). Significant penalities in WR at 174 ft/kt$^{1/3}$ are encountered only for soft targets. Table 2-1 illustrates this for VNs representing soft targets. Thus, for P VNs of about 15 or less, or Q VNs of 20 or less, the use of optimum HOB becomes important from the standpoint of increased WR. This situation can be corrected by adding 3 additional scaled heights of burst, i.e., six additinal tables in array TABWR, and suitable programming to allow matching of weapon HOB to target hardness. Moreover, direct consultation with members of the IDA staff indicates that memory limitations do not preclude a more detailed listing of WR as a function of HOB.

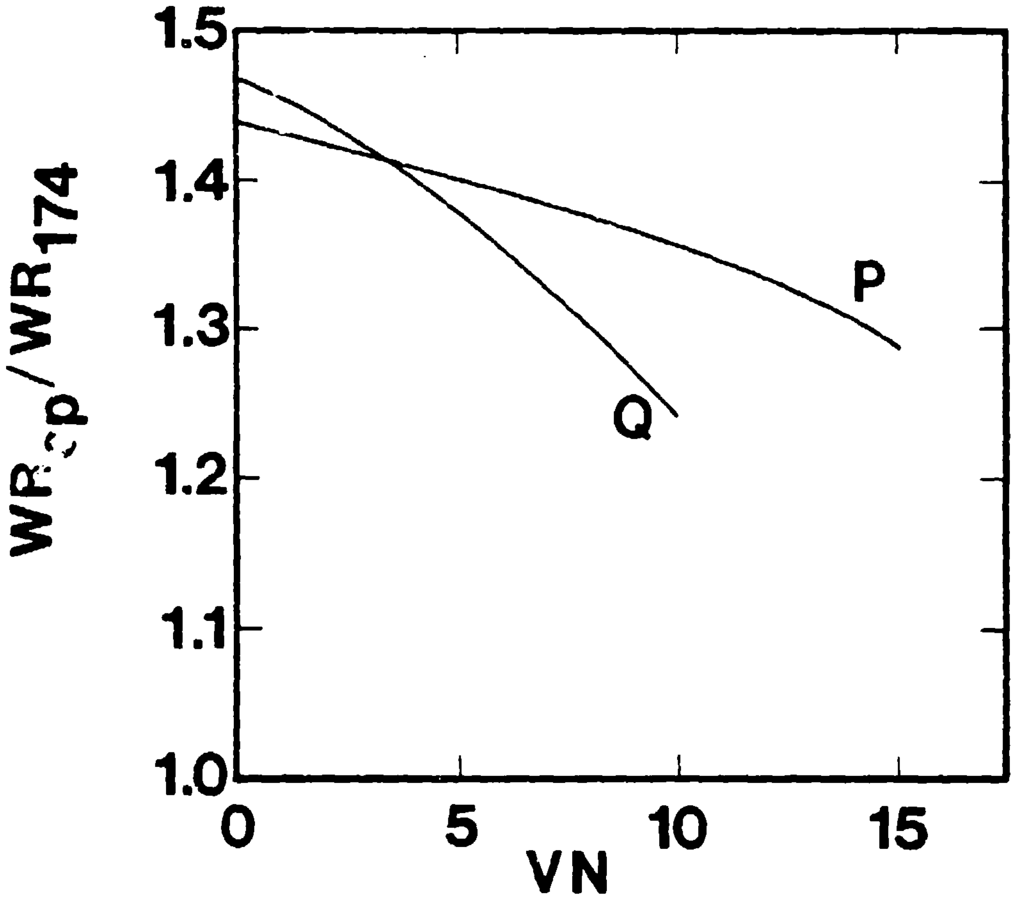

Figure 2-15 Increase in Weapon Radius by Use of Optimum HOB

Table 2-1 Comparison of weapon radii at optimum air burst altitude with those at the standard height used in TACWAR

VN	Weapon Radius (ft) for 1 kt Yield at Various Heights of Burst				Ratio of Optimum Weapon Radius to that at HOB = 174 ft
	0	174 ft	Optimum (value)	WR	
0P	3700	4225	900	6070	1.44
5P	2130	2405	900	3370	1.40
10P	1310	1387	800	1890	1.36
15P	810	827	600	1070	1.29
0Q	4080	4480	900	6580	1.47
5Q	2370	2581	900	3560	1.38
10Q	1360	1464	800	1820	1.24

For targets harder than 15P and 10Q, the relative gain in weapon radius at the optimum HOB, compared to that at 174 $ft/kt^{1/3}$, is diminishing rapidly. Accordingly, a constant value of WR for $0 \leq SHOB \leq 400$ and VN >10Q (or 15P) would be satisfactory.

There is another aspect of the height-of-burst problem which should be considered. In some wargaming studies, it may become necessary to depart from unclassified representative yields of tactical and theater weapons and to assess the impact of the use of real, operational weaponry for both sides. To accommodate such a need it will be necessary to extend the height-of-burst argument to the entire range from zero to 900 $ft/kt^{1/3}$, and to add appropriate program steps. For example a given yield and height of burst might result in a scaled height of burst (SHOB) of 650 $ft/kt^{1/3}$. In this case linear interpolation would be required. For a SHOB of 400 $ft/kt^{1/3}$, a weapon radius between those for 174 and 600 $ft/kt^{1/3}$ will be calculated by interpolation.

2-8 OFFCOV

This subroutine calculates the expected coverage of a uniform-value circular target by a cookie-cutter weapon (that is, one having a distance-damage sigma of zero) aimed with Gaussian aiming arrors at an offset aiming point. Thus, the independent parameters are the CEP of the weapon, the target radius, the offset distance, and the weapon radius. Any self-consistent set of units may be used, but in fact the calculations are made in units of weapon radius.

The Fortran listings as provided by IDA have been examined for consistency and logic flow (to confirm that all areas of input variable phase-space have been covered), but have not been verified against any original documentation. The only possible problem identified is at the beginning of the subroutine in which, prior to normalizing all dimensions into units of weapon radius, the coverage is taken to be zero for values of the weapon radius WAN < .001. This will lead to a gross error if the units of dimensions are large, and will lead to unnecessary calculations through the main algorithm if the units are small, such as meters. Normalization in units of the target radius (TER) would be appropriate: if WAN/TER < .001, set coverage equal to zero.

A complete flowchart complementing that shown in figure 82 of the CCTC documentation[13] was developed and programmed on a TI-59, with the exception of the called subroutine CIRCOV used for normalized values of the target radius less than 0.2. The results of these calculations using the OFFCOV algorithms are compared to the results obtained by direct numerical integration (kindly provided by L. Schmidt of IDA) in Appendix D, Tables D-1 to D-33. Illustrative samples of these data are shown in Figures 2-16 through 2-21 for values of the normalized target radius in the range $0.2 \leq TAR \leq 2$, in which the error in the coverage function COV is plotted against the normalized aimpoint offset for parametric values of the CEP. Errors do not exceed 30 percent for values of the independent variables which lead to target coverages in the range $0.1 \leq COV \leq 0.9$. Users of the TACWAR model should be aware, however, that if extreme targeting regimes are being used (such as preclusion oriented targeting in which a collateral damage "target"

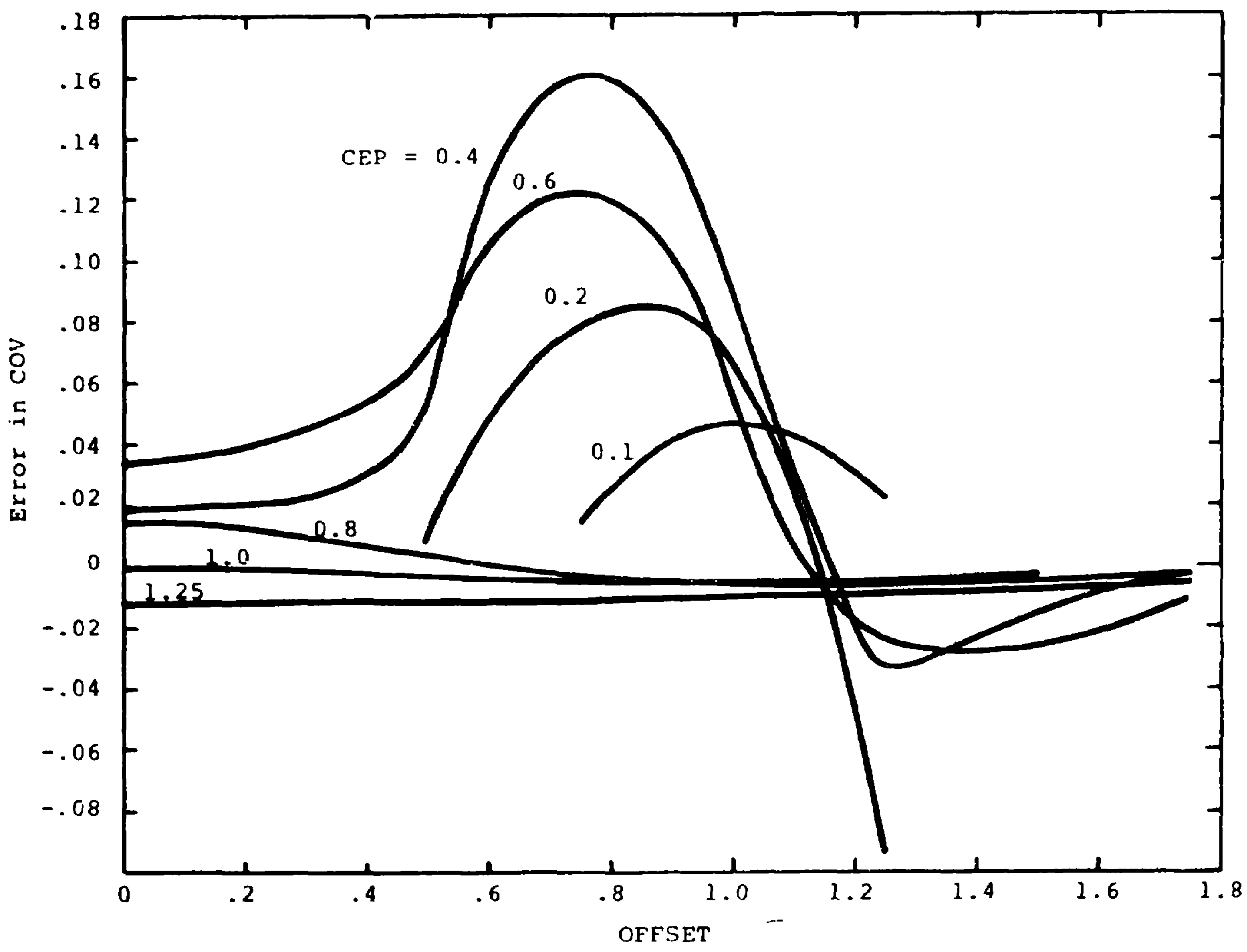

Figure 2-16. OFFCOV - Error in COV for TAR = 0.2.

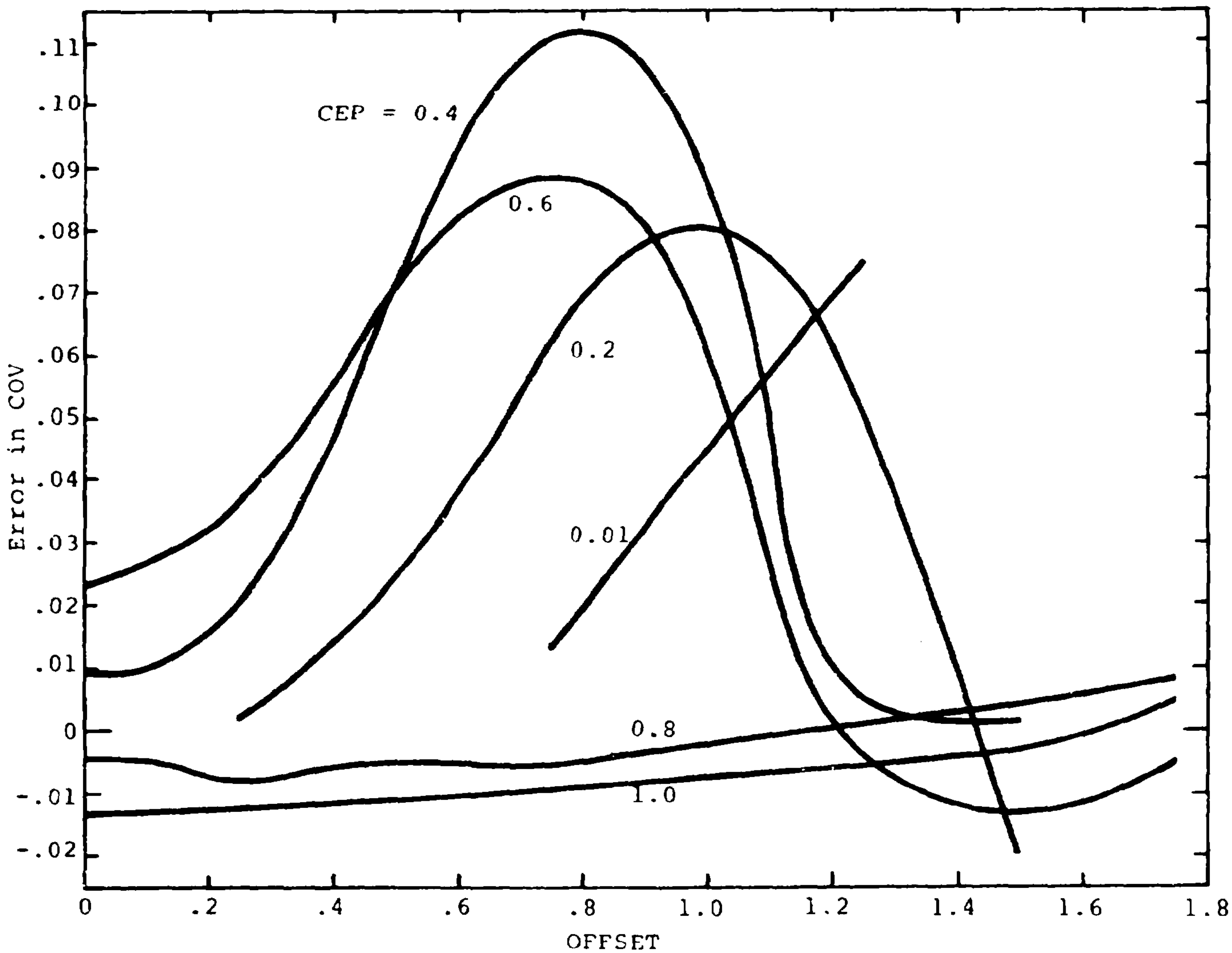

Figure 2-17. OFFCOV - Error in COV for TAR = 0.4.

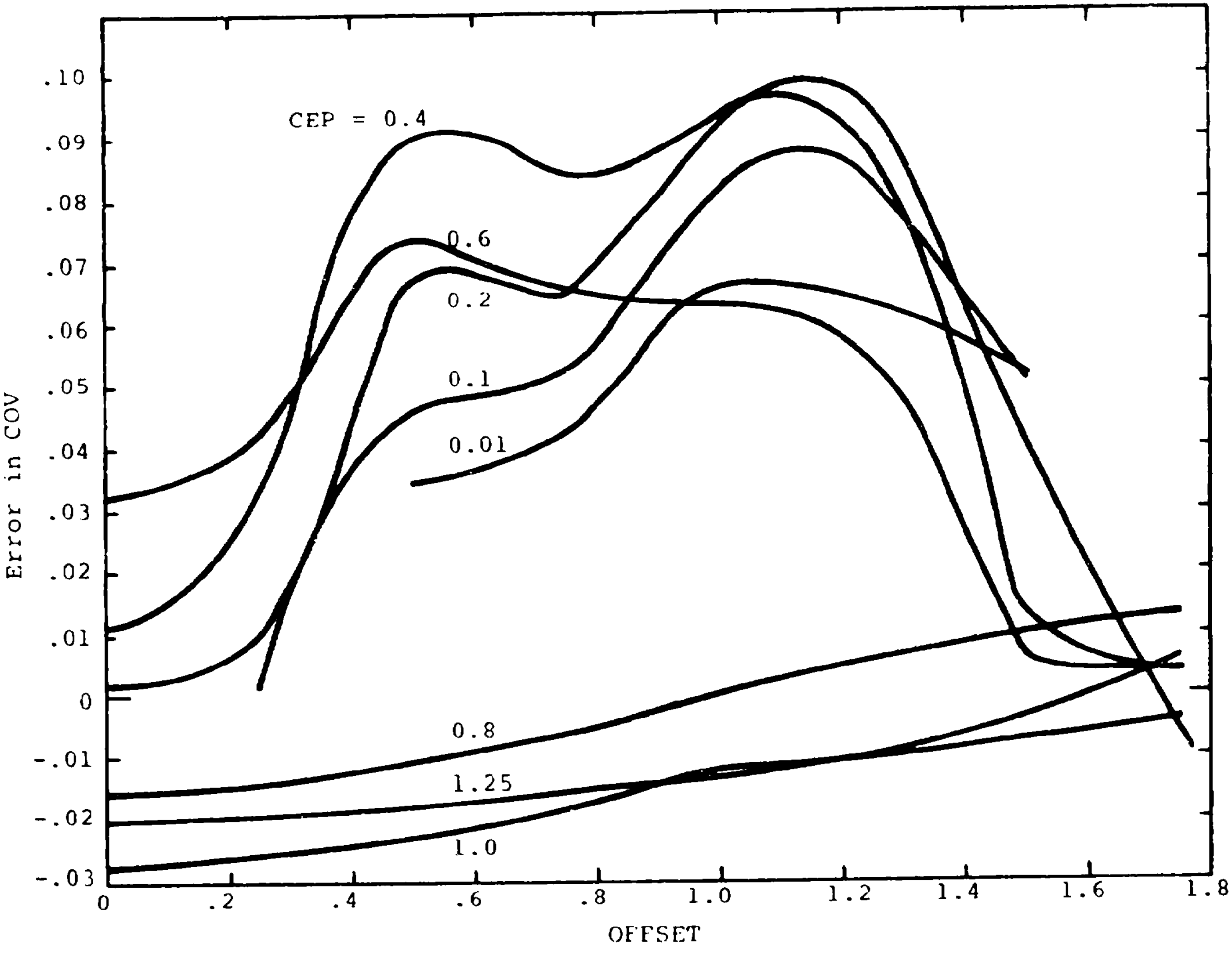

Figure 2-18. OFFCOV - Error in COV for TAR = 0.6.

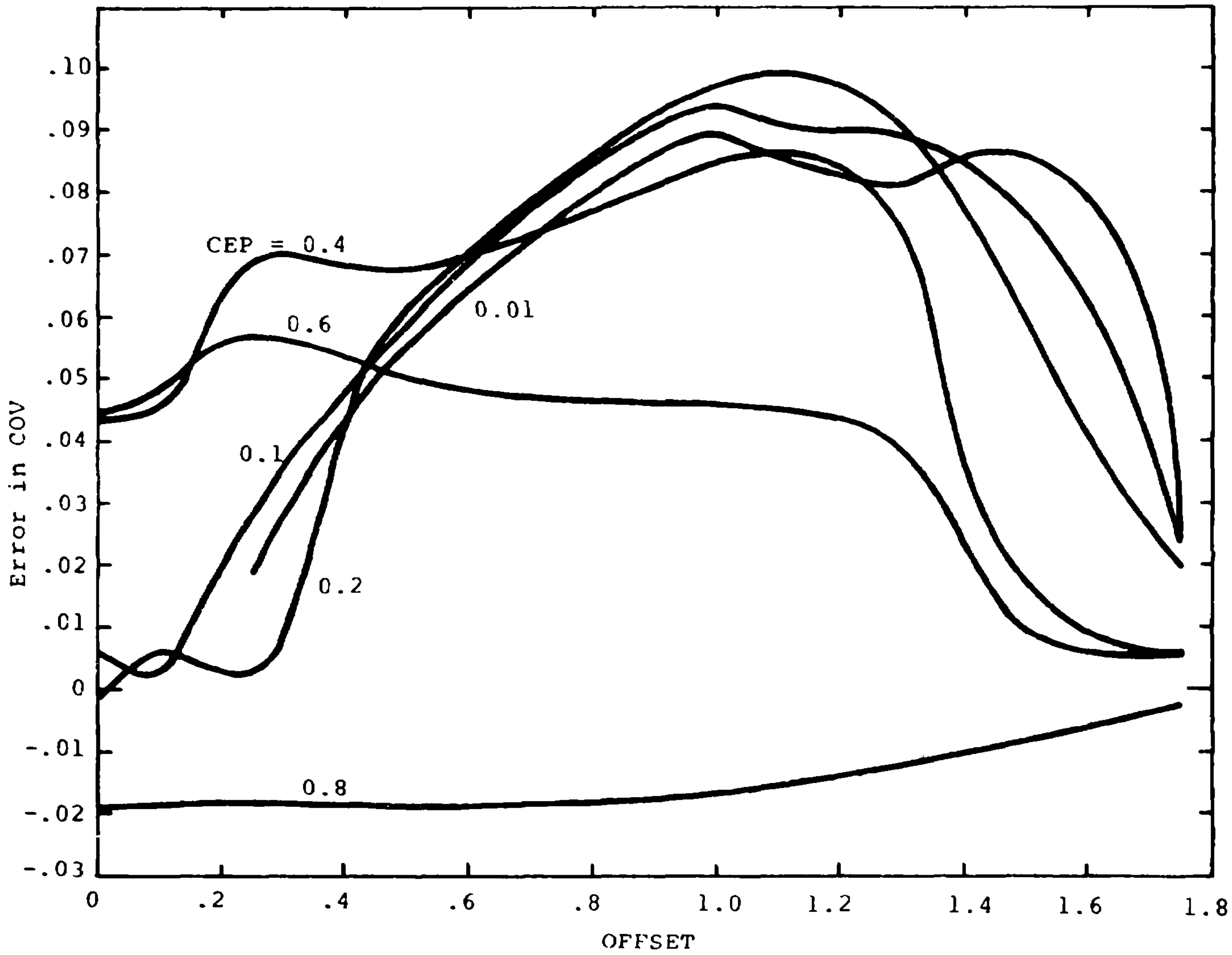

Figure 2-19. OFFCOV - Error in COV for TAR = 0.8.

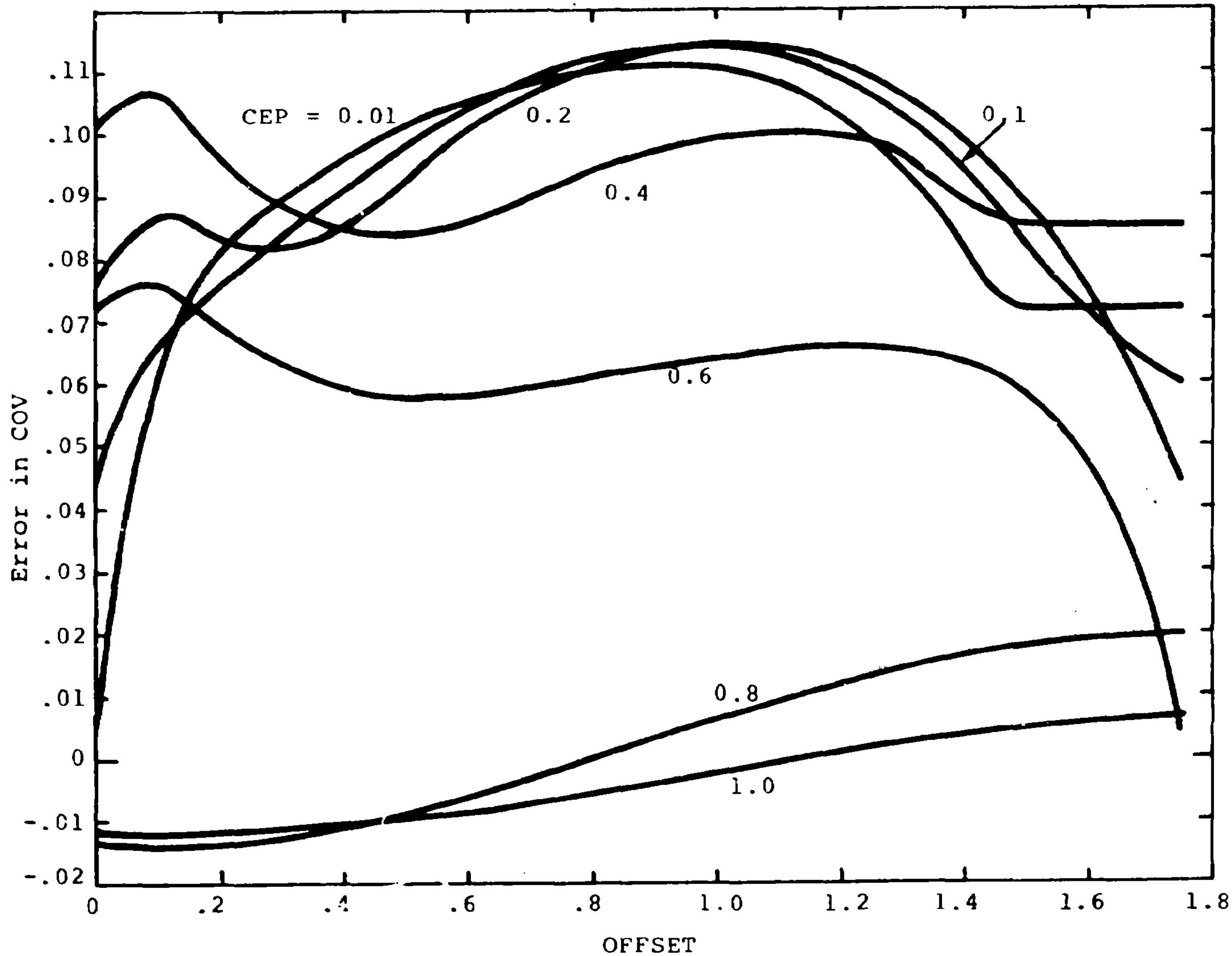

Figure 2-20. OFFCOV - Error in COV for TAR = 1.0.

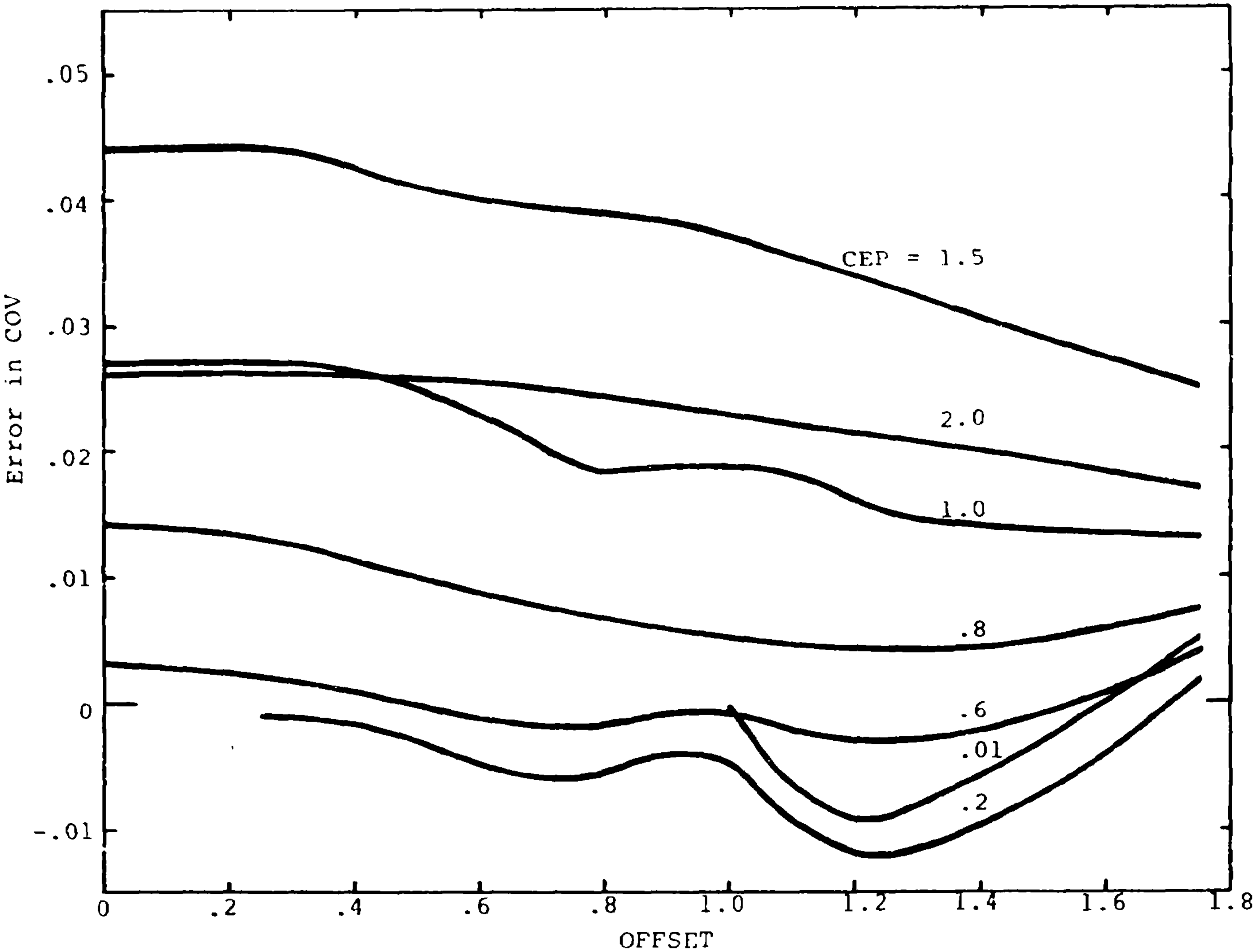

Figure 2-21. OFFCOV - Error in COV for TAR = 2.0.

coverage ≤ 0.1 might be required, or in which there are very high coverage requirements of >0.9) that the use of OFFCOV can lead to large errors. The largest absolute error identified is for TAR = 0.2, CEP = .04, OFFSET = 0.75, for which the OFFCOV algorithm calculates COV = 0.848, whereas the numerical integration gives the value of COV = 0.688.

The documentation [2,5,6] was not specifically reviewed for errors, but, where errors were noted, they have been included here. Since these errors have in general not been carried over into the Fortran statement, they will not lead to any error through use of the TACWAR model itself, but could lead to some confusion.

1. Reference 2, page C-4, the constant 1.1744 was used rather than 1.1774.

2. Reference 6, page 490, the lower left box of the flowchart contains the expression:

$$\text{COV} = \text{PNO} * \exp\left[-\left(\frac{\text{OFFSET}}{2\sigma}\right)^2\right]$$, which should be

$$\text{COV} = \text{PNO} * \exp\left[-\frac{(\text{OFFSET})^2}{2(\sigma')^2}\right]$$

2-9 SIMCN

This subroutine calculates the cumulative normal distribution function:

$$P(\text{ARG}) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\text{ARG}} e^{-\frac{t^2}{2}}\,dt$$

$$= \tfrac{1}{2}\left[1 + \sqrt{\frac{2}{\pi}}\int_0^{\text{ARG}} e^{-\frac{t^2}{2}}\,dt\right]$$

By defining $x = \left|\text{ARG}/\sqrt{2}\right|$, the integral can be put in the form of the error function:

$$P(ARG) = \tfrac{1}{2}\left[1 + \text{erf } x\right] \quad \text{if } ARG \geq 0$$

$$= \tfrac{1}{2}\left[1 - \text{erf } x\right] \quad \text{if } ARG < 0$$

in which $\text{erf } x = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2}\, dt$

An approximation[14] is used to evaluate erf x (defined as the variable CUP (x) in SIMCN):

$$\text{erf } x = 1 - (1 + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4)^{-4},$$

where $a_1 = 0.278393$ $a_2 = 0.230389$ $a_3 = 0.000972$ $a_4 = 0.078108$

and having a stated error ε, such that $|\varepsilon| \leq 5 \times 10^{-4}$. Thus,

$$P\ (ARG) = \tfrac{1}{2}\left[1 \pm CUP\ (x)\right], \qquad (1)$$

defined as the variable COV. The Fortran listing for SIMCN as supplied by IDA correctly implements this algorithm.

An alternative approximation[15] can be used for P(x), without converting to the error function first:

$$P(x) = 1 - \tfrac{1}{2}(1 + c_1 x + c_2 x^2 + c_3 x^3 + c_4 x^4)^{-4}, \qquad (2)$$

where $c_1 = 0.196854$, $c_2 = 0.115194$, $c_3 = 0.000344$, $c_4 = 0.019527$,

and having a stated error ε, such that $|\varepsilon| \leq 2.5 \times 10^{-4}$. Table 2-2 compares the tabulated data[16] with the results obtained from algorithms (1) and (2) over a range of values of ARG. Negative values of ARG are not included since they will have the same accuracies. Note that algorithms (1) and (2) are essentially identical for the trial values tabulated, differing by about one in the seventh decimal place. Neither of these algorithms differs from the exact tabulated data in the NBS handbook by more than about two in the fourth decimal place. Thus, either is totally adequate for the purposes of TACWAR.

Table 2-2. Comparison of SIMCN Algorithms

ARG	x	erf(x)(NBS)	$\frac{1}{2}$(1 + erfx)	P(x)[By(1)]	P(x)[By(2)]
$.02\sqrt{2}$	.02	.0225645747	.5112822874	.5111616872	.5111617096
$.05\sqrt{2}$	.05	.0563719778	.5281859889	.5279714679	.5279715190
$.1\sqrt{2}$	.1	.1124629160	.5562311458	.5560185655	.5560186528
$.2\sqrt{2}$	.2	.2227025892	.6113512946	.6113777352	.6113778597
$.4\sqrt{2}$	.4	.4283923550	.7141961775	.7144028313	.7144029716
$.6\sqrt{2}$	.6	.6038560908	.8019280454	.8018188151	.8018189468
$.8\sqrt{2}$	.8	.7421009647	.8710504823	.8708282008	.8708283249
$\sqrt{2}$	1.0	.8427007929	.9213503964	.9213463317	.9213464457
$1.5\sqrt{2}$	1.5	.9661051465	.9830525732	.9831705383	.9831705945
$2\sqrt{2}$	2.0	.9953222650	.9976611325	.9974330693	.9974330831

Numerous errors exist in the documentation we have available. The CCTC description[17] of SIMCN is in error in its last two expressions on page 181. They should read:

$$\text{COV} = \text{P(ARG)} = (\tfrac{1}{2})*(1 + \text{CUP}\ (\text{ARG}/\sqrt{2}))$$
$$\text{if ARG} \geq 0$$

$$\text{COV} = \text{P(ARG)} = (\tfrac{1}{2})*(1 - \text{CUP}\ (\text{ARG}/\sqrt{2}))$$
$$\text{if ARG} < 0$$

The IDA documentation[18] has errors in five expressions under the algorithm implementation. The correct expressions are:

$$\phi(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2}\, dt$$

$$A = 0.078108$$

$$\psi(x) = \frac{1}{\sqrt{2}} \int_{-\infty}^x e^{-t^2/2}\, dt$$

$$\psi(x) = \tfrac{1}{2}[1 - \phi(x)] \quad \text{if ARG} < 0$$

$$\psi(x) = \tfrac{1}{2}[1 + \phi(x)] \quad \text{if ARG} \geq 0$$

The Fortran listing itself contains none of these errors, so they are not carried forward in the model.

2-10 SIRCOV

This subroutine calculates the expected coverage of a Gaussian circular target with offset aimpoint by a weapon having Gaussian aiming errors and a cumulative log-normal distance-damage function. Thus, the variables used are the aimpoint offset, the weapon radius, the CEP, the target radius (containing 95 percent of the target area), and the distance-damage sigma (in units of the weapon radius). The algorithm implemented is that developed by Mason[19].

The Fortran listings as provided by IDA have been compared to the referenced document and reviewed for obvious errors. At tne beginning of the subroutine, prior to normalizing all dimensions into units of (adjusted) weapon radius, the coverage is set to zero for values of weapon radius WPN < 0.1. Since it is stated that the variables may be expressed in any consistent units, a large error may result if the units are large, while unnecessary calculations will be made through the main algorithm if the units are small. Use of the variable R (R = WPN/SIG), defined later in the statement, might be appropriate.

There is also a Fortran statement error in defining the adjusted CEP, taken to be:

```
CEPP = SQRT (C*C+0.213*T*T).
```

The coefficient of T^2 is, in fact, the ratio ln2/ln20, which is:

$$\ln 2/\ln 20 = 0.231378.$$

This digit inversion also appears in reference 19. It will cause an error of $\sim$ 4 percent at most in the adjusted radius (for those cases in which the CEP is small compared to the

target radius), and is used only in those parts of the subroutine in which the weapon distance-damage sigma is either 0.4 or 0.5. The minor impact which results over a range of variables will be discussed later.

An exact (to the fourth decimal place) numerical integration of this coverage function is available[20]. Normalization is in units of the weapon radius divided by the adjusted CEP (WR/CEP_a), and the offset distance divided by the weapon radius (D/WR). Tabular data are presented for distance-damage sigma of 0.1 to 0.5 in steps of 0.1. Selected data from this report are shown in the first row of each double row in Tables 2-4 through 2-8.

A detailed flow chart was made of the SIRCOV algorithm and programmed on a TI-59. The results sampled over those regions of variable space which produce a target coverage generally in the range 0.1 - 0.9 are shown in the second row of each set in Tables 2-3 through 2-7. It can be seen that errors in the coverage are generally less than 15 percent, and become this large only when the coverage drops to the 0.1 extreme. As an alternative to the tabulation of the fractional error of the fractional coverage, Figures 2-22 through 2-26 show curves of the error in coverage for the parameters WR/CEP_a, D/WR, and sigma They generally fall in the range $+0.07 > \Delta\ COV > -0.14$, with the algorithms for SIGT = 0.3 and 0.5 being the least accurate.

Tables 2-8 and 2-9, using the same normalization of variables as above, show the error caused in the fractional coverage arising from using the incorrect constant 0.213 in calculating the adjusted CEP, as discussed above. The first row of each group uses the correct constant 0.231 in the

Table 2-3. OFFSET CIRCLE PROBABILITIES
Distance Damage Sigma (SIGT) = 0.1

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20*
.1		.1583 .1586	.4928 .4879	.7746 .7760	.9229 .9246	.9951 .9945			
.5				.6597 .6623	.7941 .8017	.9270 .9289	.9925 .9967		
.7			.3915 .3830	.5568 .5591		.7929 .8034	.9210 .9523	.9893 .9913	(.9985) .9975
.9						.5676 .5825	.6546 .7319	.7533 .7981	(.8040) .8365
1	.0069 .0069	.1354 .1355	.3057 .2918	.3790 .3749	.4104 .4154	.4386 .4499	.4579 .5394	.4649 .5261	(.4630) .5215
1.1						.3157 .3192	.2720 .3382	.2017 .2412	(.1643) .1920
1.5			.1648 .1424	.1328 .1143	.0923 .0774	.0372 .0280	.0050 .0069		
2		.0842 .0841	.0679 .0466	.0259 .0148	.0073 .0034				
5	.0058 .0058	.0030 .0030							

* Numbers in ( ) are interpolations from reference 22.

Table 2-4. OFFSET CIRCLE PROBABILITIES
Distance Damage Sigma (SIGT) = 0.2

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1567 .1571	.4785 .4741	.7459 .7463	.8947 .8934	.9859 .9820			
.5				.6359 .6377	.7615 .7682	.8876 .8889	.9672 .9568	.9949 .9818	.9986 .9869
.7				.5385 .5402	.6323 .6439	.7421 .7562	.8425 .8445	.9108 .8962	.9329 .9111
.9				.4276 .4266	.4785 .4885	.5335 .5537	.5814 .6093	.6126 .6474	.6220 .6601
1	.0069 .0069	.1342 .1344	.3004 .2870	.3713 .3671	.4001 .4061	.4219 .4389	.4294 .4581	.4252 .4670	.4216 .4694
1.1				.3167 .3068	.3251 .3255	.3170 .3260	.2915 .3089	.2642 .2888	.2540 .2809
1.5			.1650 .1428	.1380 .1191	.1039 .0879	.0588 .0451	.0284 .0159	.0168 .0056	.0144 .0037
2	.0067 .0067	.0838 .0839	.0700 .0483	.0306 .0176	.0118 .0054	.0023 .0006			
5	.0058 .0058	.0031 .0031							

Table 2-5. OFFSET CIRCLE PROBABILITIES
Distance Damage Sigma (SIGT) = 0.3

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1535 .1547	.4546 .4526	.7018 .6999	.8498 .8394	.9644 .9441			
.5				.5985 .6001	.7129 .7170	.8287 .8256	.9122 .8906	.9573 .9195	.9700 .9267
.7				.5085 .5116	.5893 .6021	.6746 .6940	.7436 .7581	.7861 .7914	.7990 .8006
.9				.4074 .4087	.4495 .4640	.4859 .5173	.5065 .5548	.5132 .5751	.5142 .5808
1	.0068 .0068	.1319 .1327	.2905 .2794	.3564 .3549	.3801 .3914	.3925 .4220	.3904 .4394	.3834 .4473	.3805 .4493
1.1						.3067 .3283	.2889 .3258	.2746 .3213	.2701 .3197
1.5				.1437 .1256	.1174 .1019	.0851 .0693	.0639 .0443	.0548 .0321	.0526 .0290
2	.0067 .0067	.0831 .0834	.0734 .0510	.0387 .0222	.0216 .0094	.0108 .0023			
5	.0058 .0058	.0033 .0032							

Table 2-6. OFFSET CIRCLE PROBABILITIES
Distance Damage Sigma (SIGT) = 0.4

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1483 .1511	.4218 .4309	.6455 .6423	.7899 .7867	.9255 .9187	.9879 .9881	.9995 .9994	
.5				.5501 .5500	.6524 .6504	.7556 .7354	.8311 .8265	.8751 .8923	.8883 .8928
.7				.4687 .4710	.5362 .5377	.5995 .5887	.6417 .6611	.6620 .6686	.6671 .6690
.9				.3784 .3829	.4112 .4172	.4322 .4375	.4374 .4294	.4358 .4343	.4348 .4346
1	.0068 .0068	.1279 .1301	.2750 .2807	.3334 .3387	.3510 .3588	.3550 .3669	.3480 .3339	.3411 .3377	.3389 .3379
1.1					.2946 .3038	.2859 .3019	.2718 .2560	.2627 .2589	.2601 .2591
1.5				.1460 .1510	.1263 .1332	.1040 .1151	.0903 .0815		.0830 .0825
2	.0067 .0067	.0318 .0826	.0768 .0766	.0485 .0487	.0346 .0332	.0251 .0227	.0210 .0185	.0194 .0187	
5	.0058 .0058	.0037 .0034							

Table 2-7. OFFSET CIRCLE PROBABILITIES
Distance Damage Sigma (SIGT) = 0.5

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1401 .1471	.3811 .4005	.5791 .5835	.7163 .7174	.8662 .8746	.9622 .9697	.9950 .9976	.9992 .9997
.5				.4930 .4899	.5826 .5809	.6715 .6794	.7323 .7357	.7639 .7524	.7723 .7751
.7				.4206 .4096	.4758 .3953	.5207 .4818	.5428 .5343	.5496 .5496	.5508 .5509
.9				.3418 .2140	.3660 .2632	.3758 .3208	.3730 .3557	.3688 .3660	.3674 .3668
1	.0068 .0068	.1216 .1271	.2534 .2690	.3028 .1725					
1.1					.2674 .1704	.2576 .2077	.2461 .2303	.2398 .2370	.2382 .2375
1.5				.1427 .0573	.1277 .0705	.1121 .0859	.1031 .0953	.0994 .0980	.0984 .0982
2	.0067 .0067	.0793 .0817	.0787 .0805	.0566 .0195	.0461 .0240	.0388 .0293	.0355 .0325	.0342 .0334	.0338 .0325
5	.0058 .0058	.0044 .0037							

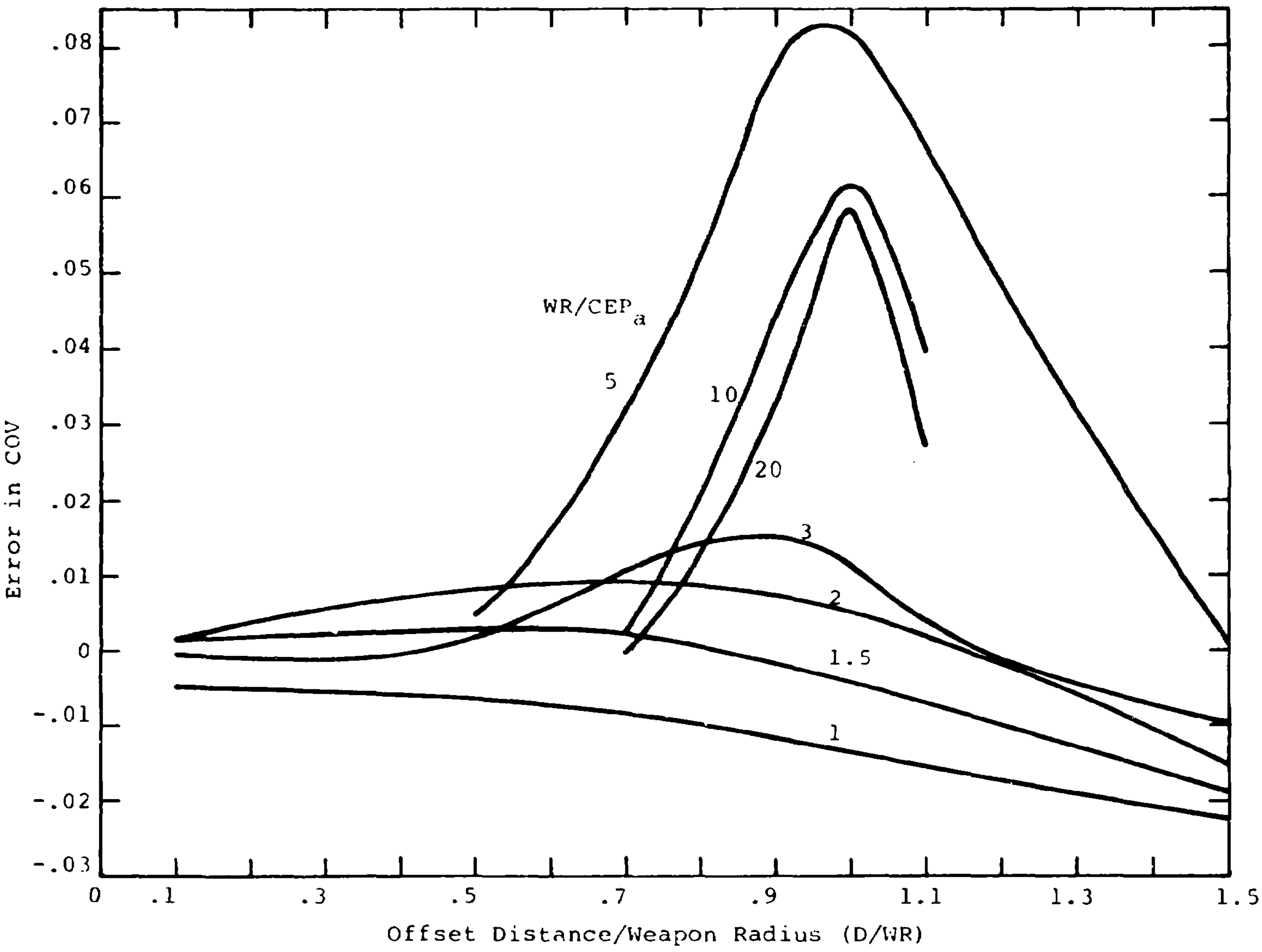

Figure 2-22. SIRCOV - Error in COV for SIGT = 0.1.

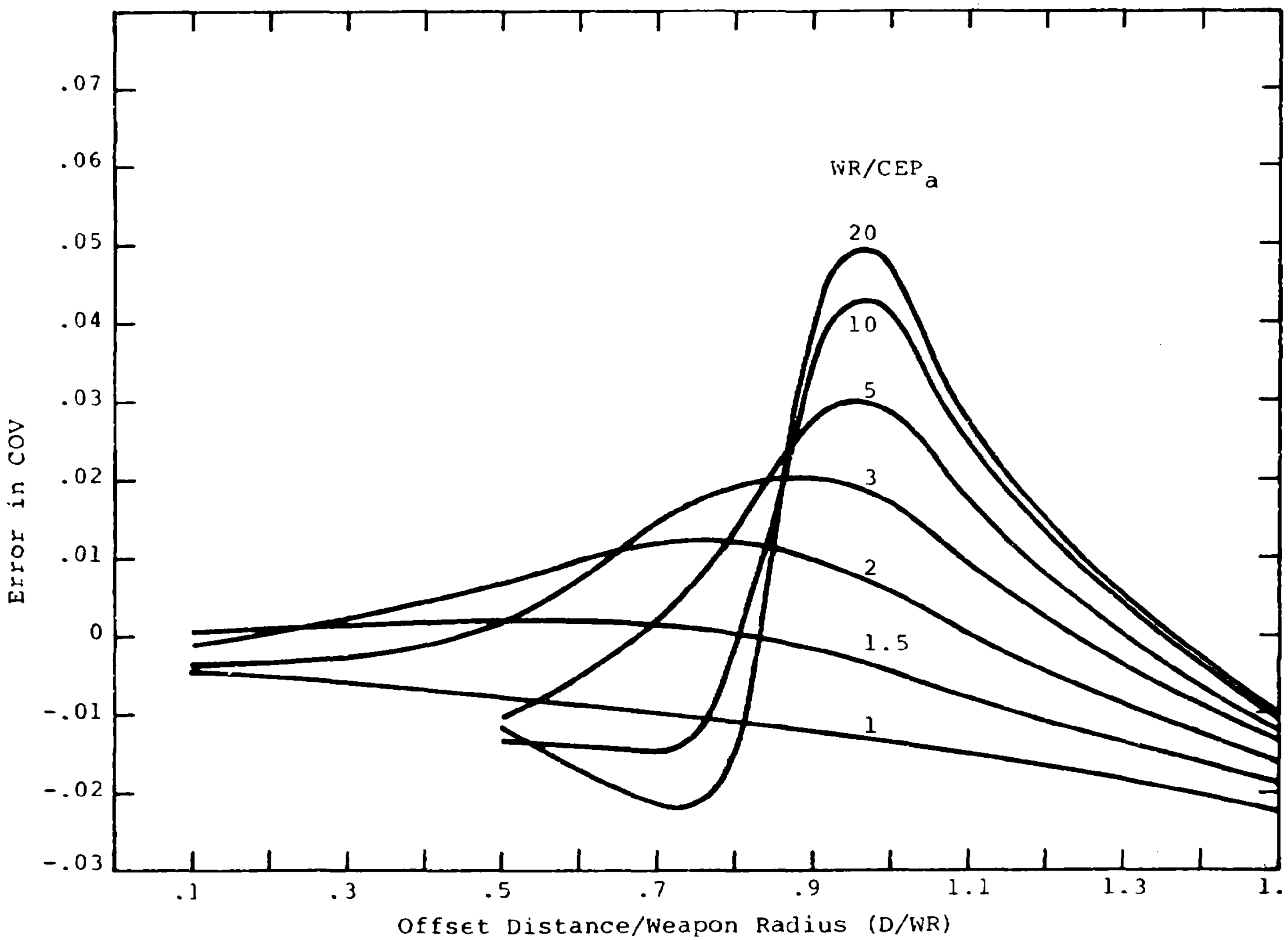

Figure 2-23. SIRCOV - Error in COV for SIGT = 0.2.

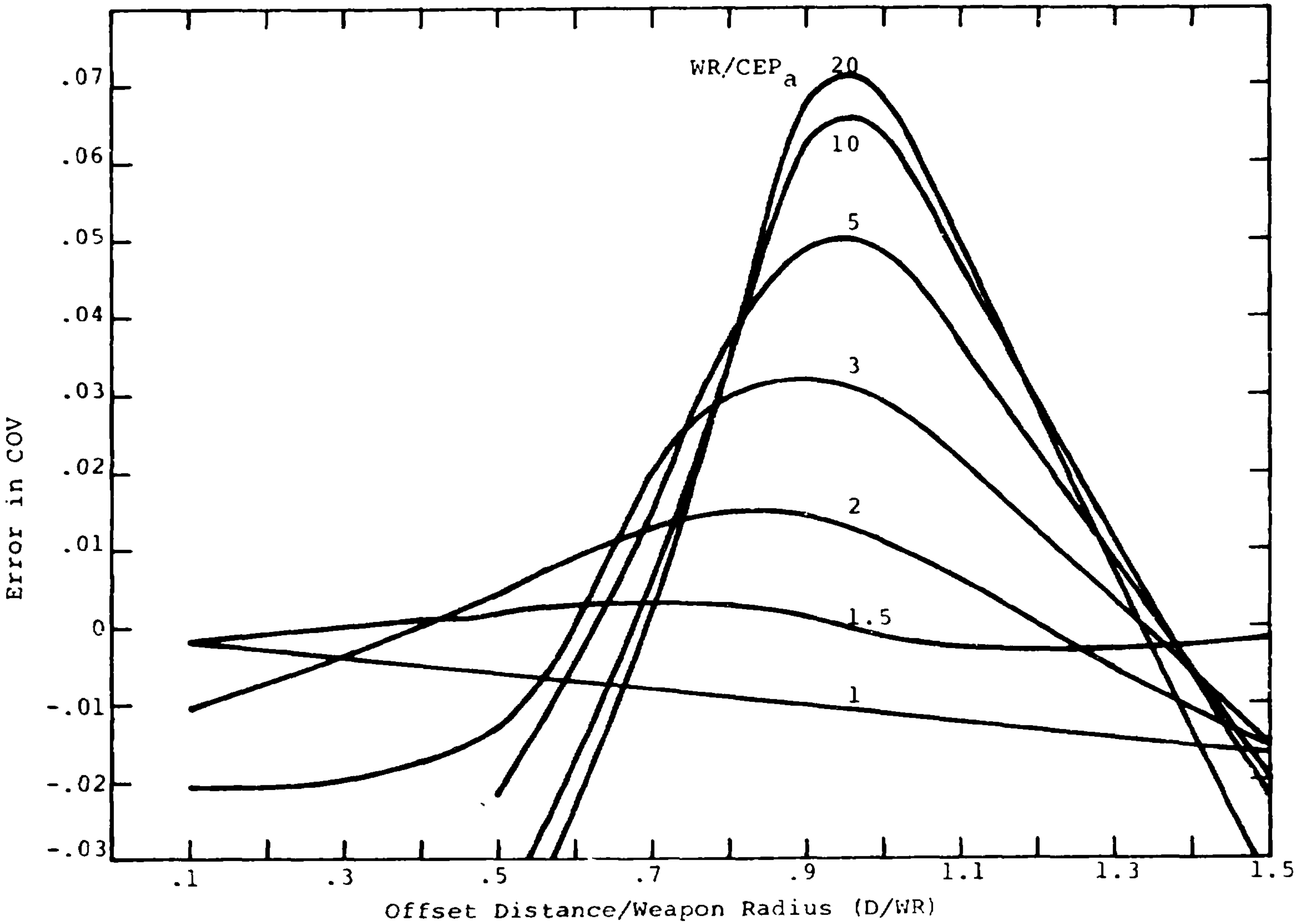

Figure 2-24. SIRCOV - Error in COV for SIGT = 0.3.

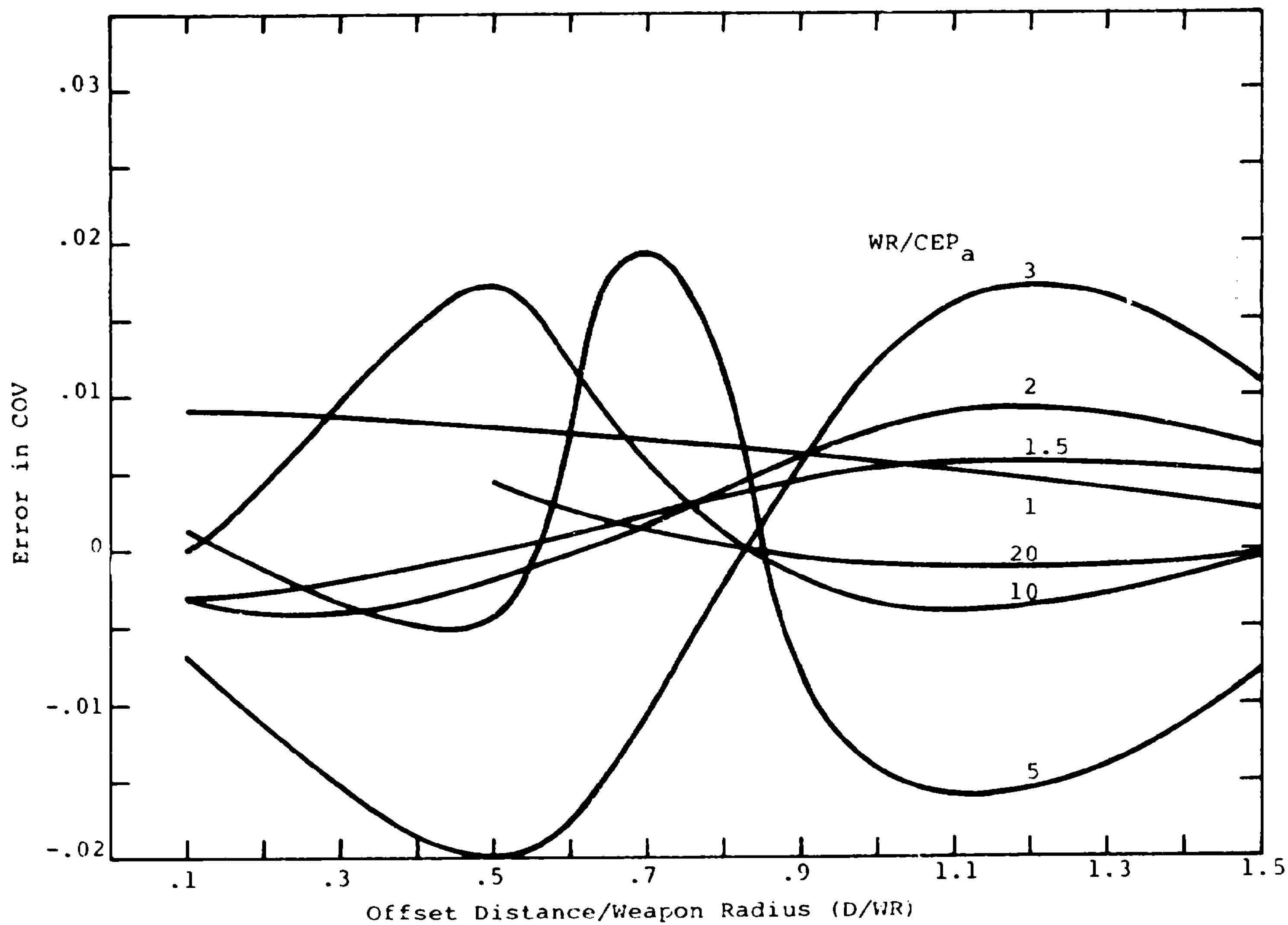

Figure 2-25. SIRCOV - Error in COV for SIGT = 0.4.

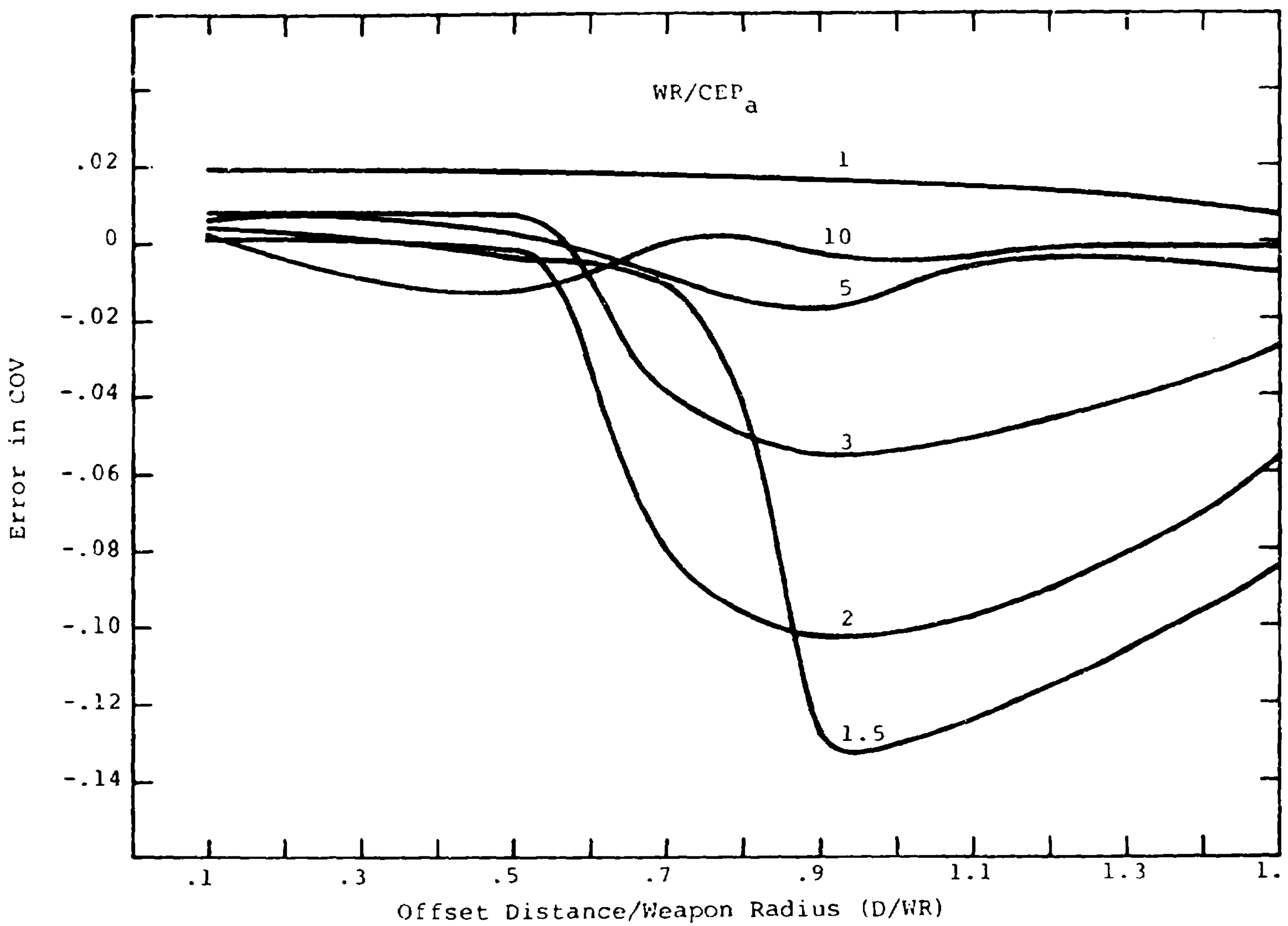

Figure 2-26. SIRCOV - Error in COV for SIGT = 0.5.

Table 2-8. OFFSET CIRCLE PROBABILITIES
Error Arising From Use of Constant 0.213.
SIGT = 0.4

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1511 .1511	.4309 .4309	.6423 .6498	.7867 .7955	.9187 .9230	.9881 .9890	.9994 .9995	
.5				.5500 .5554	.6504 .6562	.7354 .7381	.8265 .8271	.8923 .8923	.8928 .8928
.7				.4710 .4747	.5377 .5414	.5887 .5902	.6611 .6617	.6686 .6687	.6690 .6690
.9				.3829 .3851	.4172 .4188	.4375 .4380	.4294 .4298	.4343 .4343	.4346 .4346
1	.0068 .0068	.1301 .1301	.2807 .2807	.3387 .3401	.3588 .3596	.3669 .3670	.3339 .3342	.3377 .3377	.3379 .3379
1.1					.3038 .3039	.3019 .3018	.2560 .2562	.2589 .2589	.2591 .2591
1.5				.1510 .1501	.1332 .1320	.1151 .1145	.0815 .0816		.0825 .0825
2	.0067 .0067	.0826 .0826	.0766 .0766	.0487 .0478	.0332 .0324	.0227 .0224	.0185 .0185	.0187 .0187	
5	.0058 .0058	.0034 .0034							

Table 2-9. OFFSET CIRCLE PROBABILITIES
Error Arising From Use of Constant 0.213.
SIGT = 0.5

Offset Distance/Weapon Radius (D/WR)	Weapon Radius/CEP_a (WR/CEP_a) .1	.5	1	1.5	2	3	5	10	20
.1		.1471 .1471	.4005 .4005	.5835 .5835	.7174 .7271	.8746 .8803	.9697 .9716	.9976 .9978	.9997 .9997
.5				.4899 .4899	.5809 .5870	.6794 .6828	.7357 .7368	.7524 .7525	.7751 .7751
.7				.4096 .4096	.3953 .4006	.4818 .4851	.5343 .5353	.5496 .5497	.5509 .5509
.9				.2140 .2140	.2632 .2667	.3208 .3230	.3557 .3564	.3660 .3660	.3668 .3668
1	.0068 .0068	.1271 .1271	.2690 .2690	.1725 .1725					
1.1					.1704 .1727	.2077 .2091	.2303 .2308	.2370 .2370	.2375 .2375
1.5				.0573 .0573	.0705 .0714	.0859 .0865	.0953 .0955	.0980 .0980	.0982 .0982
2	.0067 .0067	.0817 .0817	.0805 .0805	.0195 .0195	.0240 .0243	.0293 .0295	.0325 .0325	.0334 .0334	.0335 .0335
5	.0058 .0058	.0037 .0037							

SIRCOV algorithm, the second the incorrect one. The largest error found was $\Delta COV = 0.01$.

Although the documentation was not specifically examined for errors, the following were noted. They have not in general been carried over into the Fortran statements.

The correct expressions in reference 2 should read:

1. Page C-8, last line: $CEP' = [C + 0.231\ (T)^2]^{\frac{1}{2}}$

2. Page C-8, last line: If SIGT $\leq$ 0.301...

3. Page C-9, line 11: P(P,O) = CUMN

   $\left[\ln \dfrac{WPN(1-SIGT^2)}{CEP'}\right/$ ...etc.

4. Page C-9, last line: ...and r > 1.5, ...

5. Page C-10, line 3: $PD = P(O)\ \exp\left\{-\left[P(O)r^2/R^2\right]\right\}$

On page 492, reference 6, the flow chart reflects the unit normalization problem discussed above in connection with the Fortran statement in which WPN $\geq$ 0.1 is used rather than the suggested R $\geq$ 0.1.

2-11 CIRCOV

This subroutine calculates the circular coverage function, which is a Gaussian function integrated over an offset circle. It is equivalent to either:

a. Probability that an impact point will fall within a circle of radius R aimed with an offset r if the impact has a Gaussian probability of unit standard deviation.

b. Probability that a point target will be covered by a weapon having an effects radius R (and a distance-damage $\sigma = 0$, i.e., a "cookie cutter" weapon) when aimed

with an offset r with an aiming error having a Gaussian probability of unit standard deviation.

The integral to be evaluated is:

$$P(R,r) = \frac{1}{2\pi}\iint e^{-(x^2 + y^2)/2}\, dx\, dy,$$

in which the integration is carried out over the circle

$$(x-a)^2 + (y-b)^2 = R^2$$

where $a^2 + b^2 = r^2$

In practice, when the distances (including the CEP aiming errors, which are generally not unity) are given in any consistent set of units, they are normalized by dividing by (CEP/1.1774).

In TACWAR, this integral is evaluated by an algorithm using an approximation in the reference 14 equations 26.3.25, 26.3.26 and 26.3.27. The Fortran statement has been carefully checked and found to correctly implement the algorithm. It was programmed on a TI-59 to generate the data shown in Figures 2-27 and 2-28, in which discontinuities at R = 1, 5 can be noted. To check the accuracy of the algorithm, a numerical integration of P(R,r) was made for a series of parametric values of the independent variables.* These (having an accuracy of several in the fifth digit) are shown in Table 2-10, along with the corresponding values from CIRCOV, and are also shown as points on Figures 2-27 and 2-28. It can be seen that for probabilities in the range 0.05 -0.95 the CIRCOV algorithm is generally accurate within 10 percent. It should be kept in mind, however, that

---

* These data cover a broad spread of parameter space. In some regions they have been confirmed by comparison to more detailed tabulations such as reference 23.

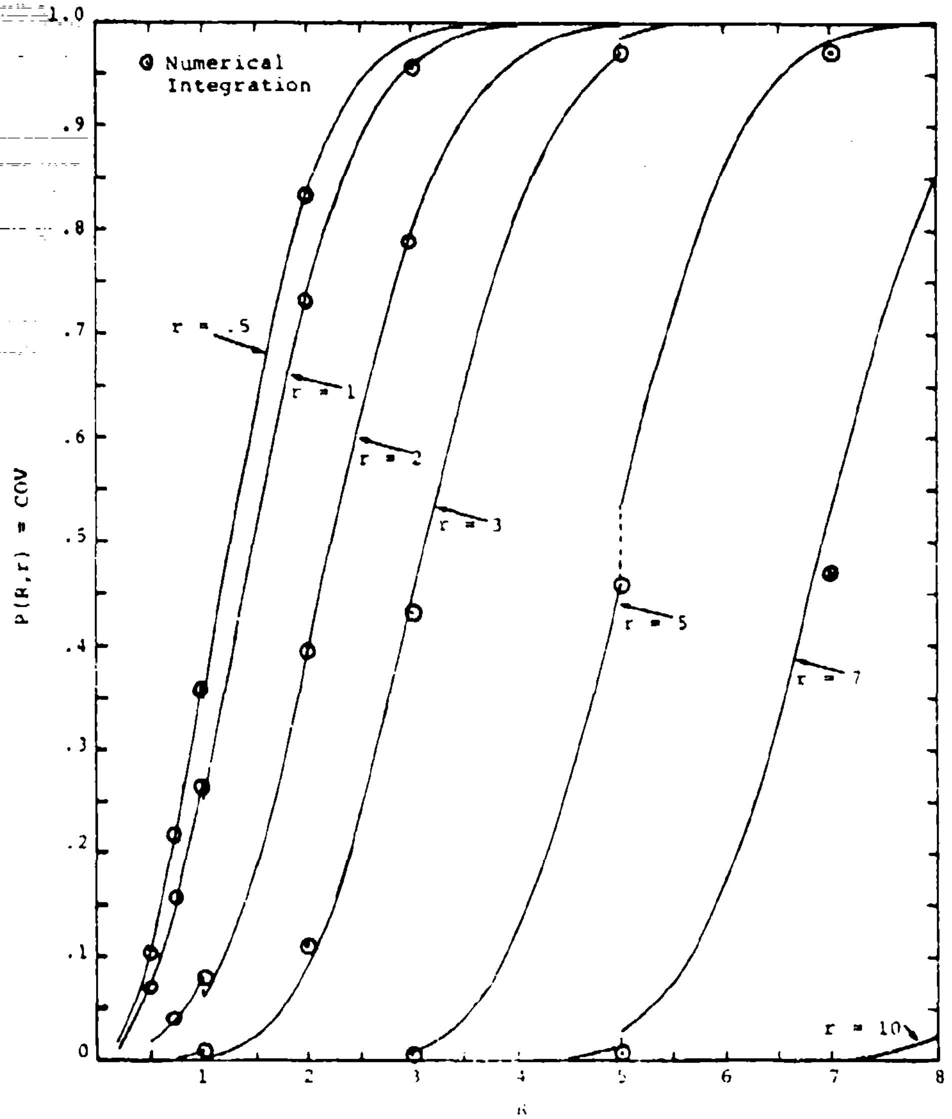

Figure 2-27. The Circular Coverage Function

CIRCOV

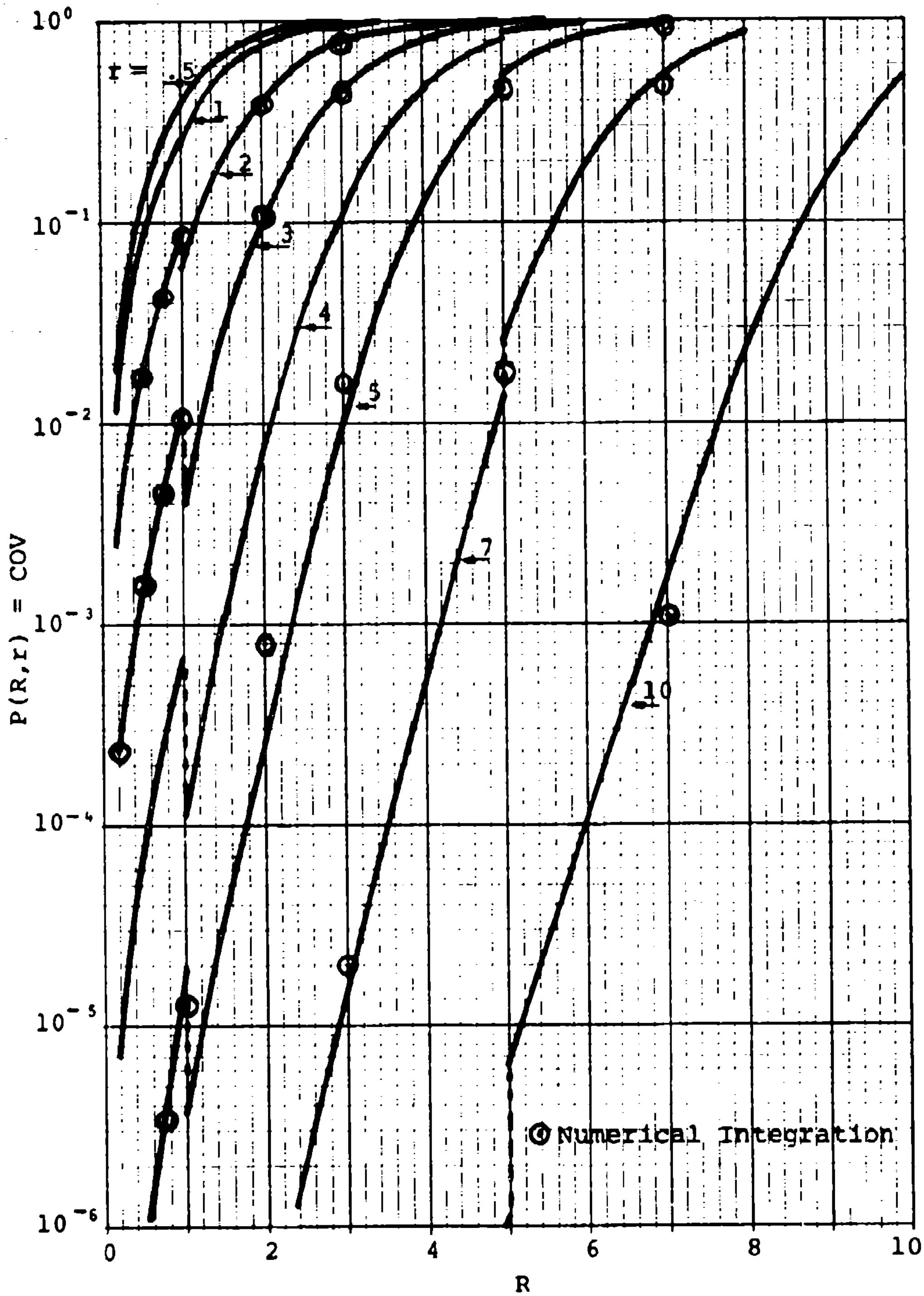

Figure 2-28. The Circular Coverage Function

CIRCOV

Table 2-10.

The Circular Coverage Function

Numerical Integration

(accuracy = several in the fifth digit)

R ↓ r →	.2	.5	.25	1	2	3	5	7	10
.2	.19413-1	.17496-1	.14989-1	.12070-1	.27336-2	.22993-3	.83377-7	.57352-12	.60670-23
.5	.11532	.10449	.90231-1	.73472-1	.17931-1	.16995-2	.87127-6	.93659-11	.21479-21
.75	.24095	.22000	.19212	.15889	.42926-1	.47420-2	.36224-5	.61481-10	.28995-20
1	.38745	.35729	.31659	.26712	.81892-1	.10829-1	.12791-4	.34850-9	.34137-19
2	.85925	.83085	.78885	.73099	.39650	.11328	.80073-3	.14721-6	.27134-15
3	.98788	.98216	.97239	.95628	.78564	.43252	.16616-1	.20055-4	.68758-12
5	.10000+1	.99999	.99997	.99993	.99778	.96932	.45990	.18556-1	.19936-6
7	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.99995	.97229	.47143	.11082-2
10	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.99836	.48003

CIRCOV

R	.2	.5	.25	1	2	3	5	7	10
.2	.19414-1	.17497-1	.14989-1	.12070-1	.27335-2	.23000-3	.83552-7	.57789-12	.62659-23
.5	.11545	.10459	.90286-1	.73486-1	.17910-1	.17030-2	.91461-6	.11383-10	.42973-21
.75	.24229	.22098	.19269	.15906	.42702-1	.47706-2	.42910-5	.11576-9	.22614-19
1	.39365	.36193	.31941	.26813	.80759-1	.10929-1	.18160-4	.12299-8	.16993-17
1.00001	.38149	.35042	.30736	.25405	.59079-1	.38822-2	.37684-5	.10879-7	.17384-10
2	.86154	.83364	.79304	.73727	.39730	.96596-1	.26941-3	.39646-6	.26215-9
3	.98793	.98246	.97306	.95764	.79690	.44219	.10466-1	.14430-4	.37756-8
5	.99996	.99992	.99985	.99971	.99633	.96691	.47022	.13980-1	.11911-5
5.00001	.99999	.99999	.99999	.99999	.99927	.98514	.54000	.26700-1	.66475-5
7	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.99994	.98231	.52840	.18213-2
10	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.10000+1	.99871	.51981

for extreme probabilities these approximation errors increase to about a factor of two at $P = 10^{-2}$ and a factor of five at $P = 10^{-5}$.

There are several minor documentation errors, not carried over into the Fortran and hence having no impact on the proper operation of the subroutine. References 2 and 5 fail to note that for $R > 5$ and $RLS < 1$, then ARG (for the called subroutine SIMCN) is set equal to R, although this branch is correctly noted on Figure 85, reference 6. Other small errors are:

1. Figure 85, reference 6, the expression

$$T2 = \frac{2}{9}\left(\frac{2+2RL^2}{(2+RL^2)^2}\right)$$

is incorrectly written.

2. Page 185, reference 5 has the inequalities

$R > 1$

and

$1 < R \leq 5$ incorrectly written.

REFERENCES

1. Kerlin, E. P., and H. E. Strickland, IDA TACNUC Model: Theater-Level Assessment of Conventional and Nuclear Combat, WSEG Report 275, vol. I, Executive Summary, October 1975, Institute for Defense Analyses, 400 Army-Navy Drive, Arlington, Va. 22202, ADB009691L.

2. Ibid., vol. II, Detailed Description.

3. Ibid., vol. III, Part I, The Chemical Model and Other Modifications, November 1977.

4. Ibid., vol. III, Part II, Program Description, November 1977.

5. Defense Communications Agency (DCA) Command & Control Technical Center, Institute for Defense Analysis Tactical Warfare (TACWAR) Model, CSM MM 237-77, Program Maintenance Manual, Part I, 6 September 1977.

6. Ibid., Part II.

7. Ibid., Part III.

8. Defense Intelligence Agency, Physical Vulnerability Handbook-Nuclear Weapons (U), AP-550-1-2-69-INT, 1 June 1969, Confidential.

9. French, R. L., and L. G. Mooney, Initial Radiation Exposure from Nuclear Weapons, RRA-T7201, 14 July 1972, Radiation Research Associates, Fort Worth, Tex., AD 745906.

10. Gritzner, M. L., E. A. Straker, T. E. Albert, and H. T. Smith, Radiation Environments from Tactical Nuclear Weapons, DNA Report 4267F, July 1976, Science Applications, Incorporated, 2109 W. Clinton Ave., Huntsville, Ala. 35085, ADA047389.

11. Glasstone, S., and P. J. Dolan, The Effects of Nuclear Weapons, 3rd ed., U. S. Departments of Energy and Defense, 1977.

12. Defense Intelligence Agency, Mathematical Background and Programming Aids for the Physical Vulnerability System for Nuclear Weapons, DI-550-27-74, 1 November 1974.

13. DCA, Part II, p. 490.

14. Abramowitz, M., and J. A. Stegun, eds., Handbook of Mathematical Functions, with Formulas, Graphs and Mathematical Tables, National Bureau of Standards, December 1972, equation 7.1.27, p. 299.

15. Ibid., equation 26.2.18, p. 932.

16. Ibid., p. 310 ff.

17. DCA, Part I, para. 2.2.6.33.2.

18. Kerlin, vol. II, p. C-7.

19. Mason, R. B., Computer Approximations of the Circular Log-Normal Damage Function, National Military Command System Support Center Technical Memorandum TM 78-72, 7 August 1972.

20. Farschon, J. W., and L. N. Matteson, Tables of Probability of Damage Calculations for Point and Circular Normal Area Targets, DNA 4051T, 19 July 1976, Science Applications, Inc., 1200 Prospect Street, LaJolla, Ca. 92037, AD A038675.

21. Germond, H. H., The Circular Coverage Function, Memorandum RM-330, January 1950, the Rand Corporation, 1700 Main Street, Santa Monica, Ca. 90406.

APPENDIX A

FUNCTIONAL DESCRIPTION OF ALGORITHMS EMPLOYED BY SUBROUTINE QKINR FOR CALCULATING INITIAL RADIATION DOSES

The following algorithms are used in the QKINR subroutine to calculate components of total dose from initial nuclear radiation. This information has been taken from program listings and from the IDA paper reprinted in Appendix B.

Neutron Dose

$$D_n = \frac{W \cdot TF \cdot CF \cdot RBE}{R_o^{\,2}} \, e^{\left[CDB + ADB \cdot R_o^{\,2} + BDB \cdot R_o\right]}$$

where R_o is the slant range from the detonation to the target, TF is a height-of-burst correction (1.0 for surface burst and a fixed value for an air burst. The value of TF is dependent only on the weapon type.), CF the neutron multicollision factor, RBE the neutron relative biological effectiveness, and W is the total yield in kt. Parameters CDB, ADB, etc., and TF are defined in Table A-1.

Air-Secondary Gamma Dose

$$D_{SG} = \frac{W \cdot TF}{R_o^{\,2}} \, e^{\left[CDA + ADA \cdot R_o^{\,2} + BDA \cdot R_o\right]}$$

Variable definitions are similar to those given above.

Table A-1. Values of Exponents and Coefficients Used in Calculating Neutron and Air-Secondary Gamma Ray Doses in Subroutine QKINR

Parameter	Weapon Type		
	Fission	Intermediate	Thermonuclear
ADA	3.67E-8*	1.00E-7	1.28E-7
ADB	3.48E-8	9.26E-8	9.36E-8
BDA	-4.42E-3	-5.09E-3	-5.15E-3
BDB	-3.22E-3	-3.81E-3	-3.70E-3
CDA	22.46	22.91	21.95
CDB	20.67	20.62	19.73
TF	2.16	2.20	2.19

* Read as 3.67×10^{-8}

Fission-Product Gamma Ray Dose

Calculation of the prompt dose from gamma rays emitted by mixed fission products is complicated by the temporal and spatial dependence of the source spectrum, medium absorption properties and source geometry. The following expressions were used in the calculation of fission-product gamma ray dose from 1 kt, 10 kt and 100 kt surface burst and air burst weapons. They were derived from Appendix B, which contains complete instructions and algorithms for use with any set of parameters of interest.

1 kt surface burst: $D_{FP} = \frac{2FF}{R_o^2} 10^{8.845 - \frac{R_o}{660} - \frac{55.2}{R_o}}$

HOB=1m, $R_o \geq 362$m **

** If the range decreases below a minimum range parameter (defined in Appendix B) additional terms are introduced in the algorithm. Representative values of minimum range are 362m, 415m, and 563m for 1, 10, and 100 kt, respectively. Ranges less than these are generally not of great interest because of (a) extremely high dose levels and (b) very high neutron dose relative to gamma ray doses.

1 kt air burst: $D_{FP} = \frac{2FF}{R_o^{\,2}} \, 10^{8.837 - \frac{R_o}{660} - \frac{64.2}{R_o}}$

HOB=53m, $R_o \geq 362$m

10 kt surface burst: $D_{FP} = \frac{20FF}{R_o^{\,2}} \, 10^{9.118 - \frac{R_o}{660} - \frac{107}{R_o}}$

HOB=1m, $R_o \geq 415$m

10 kt air burst: $D_{FP} = \frac{20FF}{R_o^{\,2}} \, 10^{9.095 - \frac{R_o}{660} - \frac{126}{R_o}}$

HOB=114m, $R_o \geq 415$m

100 kt surface burst: $D_{FP} = \frac{200FF}{R_o^{\,2}} \, 10^{9.765 - \frac{R_o}{660} - \frac{385}{R_o}}$

HOB=1m, $R_o \geq 563$m

100 kt air burst: $D_{FP} = \frac{200FF}{R_o^{\,2}} \, 10^{9.686 - \frac{R_o}{660} - \frac{393}{R_o}}$

HOB=246m, $R_o \geq 563$m

APPENDIX B

Institute for Defense Analyses
TACNUC
Working Paper WP-41
December 1975

A NUMERICAL FIT TO AN ALGORITHM WHICH COMPUTES PROMPT FISSION PRODUCT GAMMA RADIATION DOSES

Leo A. Schmidt

December 1975

A. INTRODUCTION

A computer subroutine for the calculation of the Initial Nuclear Radiation Dose has been developed by C. Eisenhauer and L. Spence of the National Bureau of Standards. This subroutine computes the dose from fission product gamma radiation, secondary gamma radiation, and neutrons. The calculations are based upon a paper by French and Mooney.[1] The calculations for secondary gamma rays and neutrons are made from equations of the form

$$D = a \exp \left[b \exp \left((cR_o)^2 \right) + d \exp (cR_o) \right] ,$$

where R_o is the slant range from weapon to monitor point. This can be implemented for relatively rapid calculation. The calculations for the fission product gamma dose, on the other hand, are much more lengthy. They require more complex expressions for dose as a function of time. These expressions must be integrated as a function of time to obtain the total dose.[2] As a result the computer routine which implements these equations is a relatively slow calculation. For analysis where the doses must be calculated a large number of times, in particular in damage assessment calculations involving many weapons and monitor points, such long running calculations can add most substantially to computer requirements.

An algorithm for a more rapid calculation of the fission product gamma dose is described below. This algorithm is a strictly numerical fit to the results of calculations of fission product gamma doses over a range of parametric values. The fit is generally within 10 to 20 percent over the range of interest. This range is for yields, W, ranging from 0.1 to 10,000 KT, scaled heights of burst (the height of burst/$W^{1/3}$) from 0 to 1,300 feet,

[1] R. L. French and L. G. Mooney, "Initial Radiation Exposure from Nuclear Weapons," Radiation Research Associates, Inc., Interim Report on OCD Contract No. DAHC20-72-C0123, RRA-T7201, 15 July 1972.

[2] The essential reason for the integration is due to the hydrodynamic buoyancy of the fireball which not only changes the distance between source and receiver, but due to changes in air density with height changes the radiation absorption in a complex manner.

and slant ranges ranging from either the minimum slant range at ground zero, or the minimum slant range where the fission product gamma dose is less than 1/20 the neutron dose, to a maximum slant range where the fission product gamma dose is about 10R. The algorithm will be described directly first, followed by a few comments concerning its development.

B. ALGORITHM FOR FISSION PRODUCT GAMMA DOSES

A maximum slant range, SRM, is computed by

$$SRM = 1{,}898 + 848.25 \cdot L + 111.241 \cdot L^2 \ ,$$

where $L = \log_{10}(W)$. If $R_o > SRM$, the Dose, D, is 0; otherwise, the following procedure is followed.

An "asymptotic logarithmic" dose, D_{asy}, is computed as follows. Let

$$R_z = 1{,}188.13 + 84.3259L + 71.2003L^2 + 12.4084L^3 - 9.7729L^4 + 2.83741L^5 \ .$$

$$D_{asy} = 7 - (R_o - R_z)/660 \ .$$

If $H_B > 0.2$, set $D_{asy} = D_{asy} + R_A$,

where H_B = scaled height of burst $((ft/(KT)^{1/3})/100)$,

$$R_A = -b \cdot H_B + c \cdot H_B{}^2 \ ,$$

with

$$b = 1.24154 \cdot 10^{-2} + 6.0937 \cdot 10^{-3}L + 3.46545 \cdot 10^{-3}L^2 + 1.534 \cdot 10^{-3}L^3 - 5.9337 \cdot 10^{-5}L^4 \ ;$$

$$c = 9.9037 \cdot 10^{-5} \quad 9.147 \cdot 10^{-5}L + 1.963 \cdot 10^{-4}L^2 + 1.83616 \cdot 10^{-4}L^3 - 1.069 \cdot 10^{-4}L^4 + 1.8162 \cdot 10^{-5}L^5 \ ;$$

Compute a difference dose, D_F, by the following procedure.

If $L \le 2.4$:

$$S_B = 362 + 74.3 \cdot L - 55.99 \cdot L^2 + 34.59 \cdot L^3 \ .$$

For $R_o \geq S_B$, let

$$D_F = D_o + m(x-x_o) ,$$

where $x = 100/R_o$;

$$D_o = -0.015 - 0.0056H_B ;$$

$$x_o = 0.055 - 0.00135H_B ;$$

$$m = m_o + m_S H_B .$$

and for $L < 1$

$$m_o = 0.552 + 0.398L + 0.25L^2 ;$$

$$m_S = 0.0518 + 0.02985L + 0.01685L^2 ;$$

and for $L \geq 1$

$$m_o = -1.71 + 2.78L ;$$

$$m_S = 0.1690 - 0.0615L .$$

For $R_o < S_B$, let

$$D_F = D_o + m(x-x_o) + c(x-100/S_B)^2 ,$$

where D_o, x_o, and m are computed as before and

$$c = \begin{cases} 0.22 + [0.575(L+1)]^4 , & L \leq 1.602 , \\ 0.22 + [1.1144(L-0.61)]^4 , & L > 1.602 . \end{cases}$$

Now if $L > 2.4$, we have:

if $R_o \geq S_B$

$$D_F = m(x-x_o) ,$$

where $x = 100/R_o$;

$$m = -74.8819 + 95.3347L - 40.2997L^2 + 6.06248L^3 ;$$

$$x_o = 0.0217(4.76-L) .$$

But if $R_o < S_B$, compute

$$D_o{'} = \alpha - \beta R_o , \text{ when } R_o \geq 200 ,$$

$$D_o{'} = \alpha - \beta R_o + \delta(200-R_o) , \text{ when } R_o < 200 ,$$

where $\alpha = -0.12445 + 0.13625L + 0.01842L^2$;

$$\beta = \begin{cases} 0.001823 - 0.000403L \ , & L \leq 4 \ , \\ 0.000208 - 0.000128(L-4) \ , & L > 4 \ ; \end{cases}$$

$$\delta = 1.5431 \cdot 10^{-3} - 5.068 \cdot 10^{-4} L + 4.923 \cdot 10^{-5} L^2 \ .$$

Now let

$$D_o = \begin{cases} D_o' \ , & H_B \leq 0.5 \ , \\ D_o' + D_H \cdot H_B \ , & H_B > 0.5 \ , \end{cases}$$

where $D_H = 0.0389 - 0.0124L$.

And let

$$D_F = 10^{D_o} \ .$$

Finally, let

$$D_r = D_{asy} - D_F \ ,$$

and

$$D' = \frac{W \cdot 10^{D_r}}{R_o^2}$$

and

$$D = D' \cdot \frac{F}{0.5} \ ,$$

where F is the weapon fission fraction.

C. COMMENT

The underlying motivation of the above schema was obtained by observing that the dose as a function of R_o asymptotically approaches an expression of the form

$$D = \frac{A \cdot W \exp(-R_o)}{R_o^2} \ ,$$

which would be obtained from a point source with no fireball rise and constant absorbing cross section. The dose becomes close to

this asymptotic expression at dose levels of 100 to 1,000R. Thus the first effort is to obtain a linear fit at far ranges for

$$\log_{10} D_{asy} = \log_{10}\left(\frac{D \cdot W}{R_o^{2}}\right) .$$

This was done assuming the same slope for all asymptotic curves. The fit was first made with $H_B = 0$; a correction for height of burst was then added. The height of burst correction ranged from about 30 percent (at maximum height of burst) for 0.1 KT yields to somewhat over 2 at large yields.

Using the "asymptotic dose," the logarithm of the ratio of asymptotic to actual dose, D_F, was estimated. This is a function that has high values for low slant ranges and decreases to zero as the two doses approach each other. D_F as a function of $1/R_o$ is almost linear near the origin, followed by a segment which, for most yields, was approximated by a parabola that is tangent to the linear piece at their intersection. The intersection occurs where the slant range has a value, SRB, that was determined by inspection from graphs of the function. At a particular height of burst, the linear segments for all yields below 250 KT could be taken, without too much forcing, to have one common intersection, for larger yields to have another different common intersection. This naturally separated the calculations into two ranges of yields, below 250 KT and above 250 KT. These intersections were height of burst dependent for low yields, but could be taken as constant for high yields. (The ordinate of the intersection is negative, which results from errors in estimating the asymptotes. In effect, the estimation of D_F also partially compensates for errors in the asymptote estimate, and gives a two-step correction.)

The slope of the linear sections was represented by a linear function of height of burst for low yields, with the coefficients for the linear function yield dependent. For the high yields, no height of burst sensitivity was needed.

For small ranges, large values of $1/R_o$, a parabolic segment was added to the linear variation whose coefficient was yield

dependent in the low yield range. For the large yield range, this procedure gave an inadequate fit, so for low values of R_o an alternative procedure was used, namely estimating $\log_{10}(D_r)$ as a function of R_o. A linear function was adequate, except for values of D_r under 200 feet, where a parabolic segment was added.

The algorithm used may seem a rather jerry-built assemblage of curve fitting procedures, as in one sense it is. The numerical values were obtained either from graph paper or simple least squares polynomial fits. The rationale for this approach is that a function of three variables is to be fit, and there is no a priori way of determining the functional forms needed for efficient fitting. The variation of dose as a function of slant range was, in fact, well approximated as a ratio of two polynomials. Unfortunately the coefficients of these polynomials did not systematically vary as a function of yield, or height of burst, rendering the development of an approximation valid for any yield or height of burst difficult. A simultaneous estimation technique with all three independent variables included seemed required. Although this was not attempted, it appeared likely that rather high order terms would be needed for any adequate polynomial approximation. Thus the method of "cut and fit" seemed more appropriate.

The original algorithm and the approximation were implemented on a Control Data 6400 computer, and compared over a range of yields, heights of burst, and slant ranges. The average time per calculation of all three types of doses for the original algorithm was 0.640 seconds, and for the approximation 0.00176 seconds.

A display of the accuracy of the approximation is presented in Table 1 where the minimum and maximum values of the ratio of fission product of doses computed by the approximation to that computed by the numerical integration is presented for various yields and scaled heights of burst over slant ranges of interest. The slant range of interest for this table is defined as any slant range where the fission product gamma dose is over 10R, and where 20 times the maximum of either the estimated or actual fission product gamma dose is less than the neutron dose. As can be seen,

Table 1. MINIMUM AND MAXIMUM RATIOS OF ESTIMATED TARGET DOSES

Yield (KT)	Scaled Height of Burst $(ft/(KT)^{1/3})$					
	0	100	180	400	750	1250
0.1	0.99 0.99	0.99 0.99	0.99 0.99	1.00 1.00	1.00 1.00	1.00 1.00
1	0.98 0.99	0.98 1.00	0.99 1.00	0.99 1.00	0.99 1.00	0.99 1.00
10	0.98 1.03	0.98 1.03	0.98 1.02	0.98 1.01	0.97 0.99	0.94 0.96
100	0.92 1.17	0.96 1.08	0.98 1.07	0.99 1.04	0.99 1.02	1.02 1.03
300	0.97 1.05	0.97 1.04	0.97 1.04	0.97 1.03	0.95 1.02	-- --
1,000	0.94 1.11	0.95 1.07	0.95 1.08	0.89 1.12	0.94 1.10	-- --
10,000	0.50 0.99	0.50 1.12	0.49 1.10	0.51 1.10	0.79 1.30	-- --
30,000	1.06 0.66	1.57 0.71	0.76 1.24	0.69 0.95	-- --	-- --

the difference is generally within 10 percent of the fission product gamma dose except for the yields of 10MT and 30MT. For these larger weapons, however, the overpressures at the dose ranges of interest are generally well over 30 psi. As can be seen in Table 1, and as is even more evident from listings as a function of slant range, the errors are quite systematic. Thus, if desired, further corrections could be readily developed to make the estimated error still closer to the actual error. Such corrections would require possibly a 20 percent to 50 percent increase in calculation time for each subroutine call. Use of this multiple approximation technique is not untypical of this approach, where the error bounds achieved are often dependent primarily on the effort expended in developing the approximations.

APPENDIX C

FORTRAN LISTING OF SUBROUTINE WRADVN

This appendix consists of the entire listing of subroutine WRADVN of the DAMEVL routine of the TACWAR code. Comment cards have been omitted, and more detailed explanations added to the right of the Fortran statements to which they apply.

This appendix serves three purposes. First, it provides an example of the degree of detail required for a thorough review of nuclear effects calculations. Second, it shows the implementation of reference C-1 on a modern digital computer and explains the program in terms understandable to readers who are not experts in Fortran programming (although some knowledge of Fortran is necessary to follow the program). Third, it shows the implementation of AP550 targeting methodology (calculation of weapon radius only) in a more advanced programming language (Fortran V) than that given in reference C-2.

Detailed Verification of Subroutine WRADVN FORTRAN Listing

Card Nos.	Reference	FORTRAN Statement	Comments
1		FUNCTION WRADVN(YIELD,HOB,IVN,WSIG,IDONUT)	This array gives the weapon radii in ft/kt$^{1/3}$ (feet scaled to 1 kt) for surface burst and air burst weapons against overpressure-sensitive (P type) and dynamic pressure-sensitive (Q type) targets. Numerical values correspond directly to those given in Tables 1-16 and 1-18 of AP550 for zero burst height (surface burst), and to an inferred burst height of 170-174 ft/kt$^{1/3}$. See References A1 and A2 for detailed description of targeting and definitions of P, Q, etc.
2		DIMENSION TABWR(60,2,2)	
3-8		DATA (TABWR(I),I= 1, 60) /3700.,3310.,2970.,2650.,2380.,2130.,	
		11910.,1720.,1600.,1440.,1310.,1180.,1070.,...... 0., 0./	
9-12		DATA (TABWR(I),I=61,96) / 4080.,3690.,3310.,2970.,2660.,	
		12370.,2120.,1900.,1700.,1520.,1360.,1220.,......160., 140.,0./	
13-17		DATA (TABWR(I),I = 121,180) /4226.,3782.,3372.,3012.,2690.,	
		1 2405.,2153.,1926.,1737.,1552.,......50.,18*0.0/	
18-21		DATA (TABWR(I),I= 181,216)/4460., 4040.,3621.,3236.,2889.,	
		1 2581.,2297.,2049.,1832.,......292.,275.,255.,235.,0.0/	
25		IHOB = 1	Defines 2 burst heights, zero and non-zero.
26		IF(HOB .GT. 0.) IHOB=2	
27		QYLD = YIELD** .333333333	Defines yield scaling coefficient.
32		IT1 = IVN/100	Isolates VN.
33		VN = IT1	
34		IT2 = IVN - 100*IT1	Isolates IPQ (1=P, 2=Q)
35		IPQ = IT2/10	
36		IF(IPQ .EQ.1 .OR. IPQ .EQ.2) GO TO 100	
37		WRITE(6,110) IVN	
38	110	FORMAT(1H0,* --- BAD INPUT OF VN TO WRADVN-- VALUE IS *	
39		1 ,I4, * STOP PROGRAM /////////*)	
40		STOP 3654	
41	100	CONTINUE	
42		IT4 = IT2 - 10*IPQ	Isolates XK.
43		XK = IT4	XK is the yield-adjustment K Factor. See Ref A2 p37.
45		WSIG = 0.2	Set damage sigmas to appropriate values for P and Q
46		IF(IPQ .EQ.2) WSIG = 0.3	targets. See ref. A2 p34.
47		IDONUT = 1	Apparently redundant, since no further reference appears.
51		IF(XK .EQ.0.) GO TO 2000	
60		ALPHA = 1. - 0.1*XK	Alpha is the first two terms, and beta the coefficient of the last term, of the equations for the yield adjustment factor, K, given at the top of page 39 of ref. A2.
61		BETA = 0.271442*XK/QYLD	
64		IF(IPQ .EQ.2) GO TO 200	

Card Nos.	Refer-ence	FORTRAN Statement	Comments
68		R2 = 0.5* (BETA + SQRT(BETA*BETA + 4.*ALPHA))	Changes variable (see ref. A2, p39); for P type targets, $R2 = R^{1/2}$. Then $(R2)^2 = \alpha + \beta(R2)$ and $R2 = \beta/2 + \frac{1}{2}(\beta^2+4\alpha)^{1/2}$ from the quadratic formula. From ref. A2 p39 we have $VN = VN + 5.485\ell n(R)$ where $\ell n(R) = 2\ell n(R2)$; thus $VN_a = VN + 10.97\ell n(R2)$.
69		VN = VN + 10.97*ALOG(R2)	
70		IF(VN .GT. 55.) GO TO 90	
71		GO TO 2010	
74	200	CONTINUE	
77		QTST = ALPHA*ALPHA/4. - BETA*BETA*BETA/27.	Forms test quantity to solve cubic equation for R in the case of Q type targets. Here let $R3 = R^{1/3}$ in the second equation at the top of page 39 of ref. A2. For solution of the cubic see, for example, ref. A3 p318. Here $(R3)^3 - \beta(R3) - \alpha = 0$, which corresponds to $x^3 + ax + b = 0$, with $a = -\beta$ and $b = -\alpha$. Card 77 forms the test quantity for finding roots of the cubic.
78		IF(QTST .LT. 0.) GO TO 210	
79		QRT = SQRT(QTST + 0.0000001).	In case the test quantity is just zero a bias of 10^{-7} is added, and $R3 = [\alpha/2 - (\alpha^2/4 - \beta^3/27)^{1/2}]^{1/3} + [\alpha/2 + (\alpha^2/4 - \beta^3/27)^{1/2}]^{1/3}$
80		TEMP = 0.5*ALPHA - QRT	
81		TEMPA = (ABS(TEMP))**0.333333333	
82		R3 = (0.5*ALPHA + QRT)**0.333333333 + SIGN(TEMPA,TEMP)	
83	211	CONTINUE	
84		VN = VN + 8.226*ALOG(R3)	From ref. A2 p39 for Q type targets $VN_a = VN + 2.742\ \ell nR$ where $\ell nR = 3\ell nR3$, thus $VN_a = VN + 8.226\ell nR3$.
85		IF(VN .GT. 36) GO TO 90	
86		GO TO 2010	
87	210	CONTINUE	
88		RTB = SQRT (BETA)	If the inequality of card 78 is satisfied, ref. A3 defines $\phi = \arccos[(\alpha/2)/(\beta)^{3/2} \div (27)^{1/2}] = \arccos(2.5981\ \alpha/\beta^{3/2})$, and $R3 = (2/\sqrt{3})\sqrt{\beta}\cos(\phi/3)$ or $R3 = 1.1547\sqrt{\beta}\cos(\phi/3)$
89		ANGC = ACOS(2.5980762*ALPHA/(BETA*RTB))	
90		R3 = 1.1547*RTB*COS(ANGC/3.)	
91		GO TO 211	
95	2000	CONTINUE	
96		IF((IPQ .EQ.1 .AND. VN .GT. 55.) .OR. (IPQ .EQ. 2 .AND.VN .GT.	
97		1 36.)) GO TO 90	
98	2010	CONTINUE	
99		IF(VN .LT. 0.) GO TO 90	
104		IV = VN + 1	Increases VN by one so as to be compatible with TABWR, where VN = 0 is at I = 1, etc.
105		IVV = IV + 1	

Card Nos.	Refer-ence	FORTRAN Statement	Comments
106		FRAC = VN + 1. - FLOAT(IV)	Finds the fractional value of VN for logarithmic interpolation.
108		WR1 = TABWR(IV,IPQ,IHOB)	Sets upper end of interpolation interval around VN.
109		IF(FRAC .GT. 0.0001) GO TO 2050	Jumps to interpolation routine.
110		WRADVN = QYLD*WR1	Scales weapon radius by cube root of yield, without interpolation if fractional value of VN ≤ (VN) + .0001.
111		RETURN	
112	2050	CONTINUE	
114		WR2 = TABWR(IVV,IPQ,IHOB)	Sets lower end of interpolation interval for fractional value of VN.
116		IF (WR2 .LE.0.) GO TO 2100	
118		WRADVN = QYLD*WR1*(WR2/WR1)**FRAC	Carries out logarithmic interpolation for fractional value of VN.
119		RETURN	
121	2100	CONTINUE	
122		IF(WR1 .GT. 0.) GO TO 2200	
123		WRADVN = 0.	
124		RETURN	
125	2200	CONTINUE	
126		WRADVN = QYLD*WR1*FRAC	Provides for linear interpolation if lower value of WR is 0.
127		RETURN	
131	90	CONTINUE	
132		WRADVN = 0.	
133		WRITE(6,91) IVJ,VN	
134	91	FORMAT(1H0, *--- FOR INPUT VN OF *, I4,* ADJUSTED VN OF*,F9.3,	
135		1 * IS OUT OF RANGE - 0 WEAPON RADIUS RETURNED FROM WRADVN*)	
136		RETURN	
139		END	

REFERENCES

C-1. Defense Intelligence Agency, Physical Vulnerability Handbook-Nuclear Weapons (U), AP-550-1-2-69-INT, 1 June 1969, with changes, Confidential.

C-2. Defense Intelligence Agency Directorate for Intelligence, Mathematical Background and Programming Aids for the Physical Vulnerability System for Nuclear Weapons, DI-550-27-74, 1 November 1974, with Change 1.

C-3. Hodgman, Charles D., et al, editors., Handbook of Chemistry and Physics, Forty-first ed., 1959-60, Cleveland: Chemical Rubber Publishing Company, 1959.

APPENDIX D

TABULATED COMPARISONS OF SUBROUTINE OFFCOV WITH EXACT NUMERICAL INTEGRATION

This appendix contains the results of comparing the output of TACWAR subroutine OFFCOV with numerical integrations of the coverage function. Arguments are identified as follows: TAR (target radius/weapon radius), CEP (circular error probable/weapon radius), OFFSET (aimpoint offset/weapon radius). The ratio of the coverages (OFFCOV algorithm/numerical integration) is also tabulated.

Table D-1. OFFCOV

	TAR = .2 CEP = .01			TAR = .2 CEP = .1		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.10	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.25	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.50	1.000000	1.000000	1.000000	0.999996	1.000000	1.000004
0.75	1.000000	0.999094	0.999094	0.969802	0.984279	1.014928
1.00	0.478700	0.502468	1.049651	0.473275	0.519671	1.098032
1.25	0.000000	0.000000		0.022538	0.000000	
1.50	0.000000	0.000000		0.000001	0.000000	
1.75	0.000000	0.000000		0.000000	0.000000	
2.00	0.000000	0.000000		0.000000	0.000000	
2.50	0.000000	0.000000		0.000000	0.000000	
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	
	TAR = .2 CEP = .2			TAR = .2 CEP = .4		
0.00	0.999999	1.000000	1.000001	0.981697	1.000000	1.018644
0.10	0.999998	1.000000	1.000002	0.978737	0.999279	1.020989
0.25	0.999917	1.000000	1.000083	0.960735	0.982487	1.022641
0.50	0.992280	0.999780	1.007553	0.874800	0.926992	1.059662
0.75	0.875327	0.953758	1.089602	0.688066	0.848319	1.232904
1.00	0.460922	0.528213	1.145992	0.426757	0.511913	1.199543
1.25	0.087235	0.000000		0.192869	0.160183	0.830525
1.50	0.004098	0.000000		0.060244	0.045095	0.748543
1.75	0.000026	0.000000		0.012414	0.008522	0.686476
2.00	0.000000	0.000000		0.001598	0.001081	0.676485
2.50	0.000000	0.000000		0.000001	0.000005	0.526146
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-2. OFFCOV

	TAR = .20 CEP = .60			TAR = .20 CEP = .80		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.841409	0.875704	1.040759	0.649135	0.663456	1.022061
0.10	0.837335	0.871639	1.040969	0.645343	0.659146	1.021389
0.25	0.810029	0.850731	1.050248	0.625746	0.636977	1.017948
0.50	0.710831	0.781636	1.099609	0.559873	0.563713	1.006859
0.75	0.562253	0.683683	1.215970	0.463446	0.459849	0.992239
1.00	0.395558	0.451101	1.140418	0.353211	0.345777	0.978952
1.25	0.232813	0.208531	0.895701	0.2464[illegible]	0.239662	0.972528
1.50	0.121452	0.096249	0.792486	0.156440	0.153118	0.978764
1.75	0.048157	0.036988	0.768062	0.089827	0.090173	1.003848
2.00	0.017725	0.011834	0.667669	0.046394	0.048949	1.055080
2.50	0.001145	0.000699	0.482238	0.008836	0.011297	1.278513
3.00	0.000009	0.000020	2.205971	0.001046	0.001882	1.799428
4.00	0.000000	0.000000		0.000003	0.000020	6.552871
	TAR = .20 CEP = 1.0			TAR = .20 CEP = 1.25		
0.00	0.493950	0.492640	0.997348	0.356136	0.344285	0.966722
0.10	0.491633	0.490215	0.997115	0.354902	0.343066	0.966649
0.25	0.479637	0.477675	0.995910	0.348494	0.336738	0.966265
0.50	0.439019	0.435454	0.991880	0.326521	0.315075	0.964946
0.75	0.378493	0.373214	0.986053	0.292882	0.282023	0.962925
1.00	0.306976	0.300733	0.979662	0.251435	0.241493	0.960458
1.25	0.233853	0.227829	0.974241	0.206517	0.197821	0.957891
1.50	0.167030	0.162272	0.971515	0.162218	0.155020	0.955627
1.75	0.111641	0.108664	0.973334	0.121798	0.116212	0.954139
2.00	0.069692	0.068412	0.981634	0.087367	0.083342	0.953931
2.50	0.921960	0.022534	1.026161	0.039109	0.037526	0.959528
3.00	0.005153	0.005799	0.942542	0.014484	0.014151	0.977033
4.00	0.000112	0.000183	1.635783	0.001105	0.001182	1.069899

Table D-3. OFFCOV

OFFSET	TAR = .20 CEP = 1.5 NUM. INT.	TACWAR	RATIO	TAR = .20 CEP = 1.175 NUM. INT.	TACWAR	RATIO
0.00	0.264606	0.255494	0.965565	0.391721	0.380185	0.970551
0.10	0.263919	0.254823	0.965535	0.390236	0.378704	0.970449
0.25	0.260340	0.251328	0.965386	0.382528	0.371022	0.969920
0.50	0.247947	0.239234	0.964863	0.356191	0.344834	0.968116
0.75	0.228577	0.220358	0.964465	0.316174	0.305232	0.965372
1.00	0.203955	0.196406	0.962988	0.267433	0.257310	0.962147
1.25	0.176126	0.169396	0.961788	0.215435	0.206581	0.958903
1.50	0.147179	0.141375	0.960564	0.165175	0.157955	0.956287
1.75	0.118999	0.114173	0.959445	0.120444	0.115022	0.954987
2.00	0.093078	0.089223	0.958582	0.083464	0.079770	0.955742
2.50	0.051518	0.049371	0.958316	0.034287	0.033142	0.966602
3.00	0.024919	0.023952	0.961202	0.011377	0.011328	0.995675
4.00	0.003865	0.003800	0.983135	0.000645	0.000737	1.142387

OFFSET	TAR = .20 CEP = 2.0 NUM. INT.	TACWAR	RATIO	TAR = .20 CEP = 4.0 NUM. INT.	TACWAR	RATIO
0.00	0.159507	0.154312	0.967433	0.042711	0.039992	0.936329
0.10	0.159256	0.154069	0.967426	0.042693	0.039975	0.936327
0.25	0.157943	0.152793	0.967395	0.042598	0.039886	0.936332
0.50	0.153343	0.148325	0.967275	0.042262	0.039570	0.936313
0.75	0.145970	0.141166	0.967090	0.041706	0.039050	0.936326
1.00	0.136240	0.131720	0.966826	0.040941	0.038334	0.936318
1.25	0.124673	0.120499	0.966518	0.039978	0.037432	0.936307
1.50	0.111858	0.108073	0.966165	0.038832	0.036358	0.936287
1.75	0.098397	0.095030	0.965782	0.037520	0.035129	0.936261
2.00	0.084860	0.081924	0.965399	0.036060	0.033762	0.936262
2.50	0.059475	0.057376	0.964701	0.032785	0.030694	0.936221
3.00	0.038502	0.037125	0.964245	0.029183	0.027321	0.936185
4.00	0.012702	0.012258	0.965081	0.021701	0.020314	0.936069

Table D-4. OFFCOV

	TAR = .20 CEP = 8.0			TAR = .40 CEP = .01		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.010866	0.010000	0.920302	1.000000	1.000000	1.000000
0.10	0.010865	0.009999	0.920294	1.000000	1.000000	1.000000
0.25	0.010859	0.009993	0.920276	1.000000	1.000000	1.000000
0.50	0.010837	0.009973	0.920284	1.000000	1.000000	1.000000
0.75	0.010800	0.009940	0.920335	0.844969	0.857580	1.014924
1.00	0.010749	0.009893	0.920355	0.457357	0.502319	1.098309
1.25	0.010685	0.009833	0.920277	0.112798	0.188174	1.668239
1.50	0.010606	0.009761	0.920294	0.000000	0.000000	
1.75	0.010513	0.009676	0.920384	0.000000	0.000000	
2.00	0.010408	0.009578	0.920295	0.000000	0.000000	
2.50	0.010159	0.009349	0.920283	0.000000	0.000000	
3.00	0.009862	0.009076	0.920338	0.000000	0.000000	
4.00	0.009146	0.008417	0.920335	0.000000	0.000000	
	TAR = .40 CEP = .20			TAR = .40 CEP = .40		
0.00	0.999941	1.000000	1.000059	0.961598	0.970921	1.009696
0.10	0.999834	1.000000	1.000166	0.957524	0.968094	1.011040
0.25	0.998202	1.000000	1.001802	0.933373	0.953532	1.021598
0.50	0.962054	0.986726	1.025645	0.835403	0.905123	1.083456
0.75	0.776654	0.838987	1.080258	0.653651	0.764220	1.169156
1.00	0.446212	0.525717	1.178177	0.419988	0.507930	1.209392
1.25	0.150935	0.200971	1.331509	0.208849	0.214443	1.026784
1.50	0.020179	0.000000		0.076234	0.078489	1.029585
1.75	0.000626	0.000000		0.019565	0.020012	1.022861
2.00	0.000001	0.000000		0.003433	0.003554	1.035365
2.50	0.000000	0.000000		0.000021	0.000038	1.804871
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-5. OFFCOV

	TAR = .40 CEP = .60			TAR = .40 CEP = .80		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.813750	0.837241	1.028868	0.628177	0.624134	0.993564
0.10	0.806641	0.833717	1.033566	0.624308	0.620388	0.993721
0.25	0.778982	0.815557	1.046952	0.608673	0.601087	0.987537
0.50	0.685311	0.755190	1.101967	0.541955	0.536928	0.990725
0.75	0.545403	0.632841	1.160318	0.450957	0.444851	0.986459
1.00	0.385217	0.446640	1.159450	0.343778	0.341847	0.994382
1.25	0.239723	0.235844	0.983820	0.242562	0.243651	1.004489
1.50	0.125739	0.122541	0.974569	0.155107	0.161073	1.038465
1.75	0.057560	0.053642	0.931932	0.090869	0.098764	1.086882
2.00	0.021056	0.019783	0.939541	0.047901	0.056168	1.172594
2.50	0.001764	0.001609	0.912139	0.009711	0.014496	1.492704
3.00	0.000050	0.000066	1.318612	0.001231	0.002769	2.249065
4.00	0.000000	0.000000		0.000001	0.000041	4.093881

	TAR = .40 CEP = 1.0			TAR = .40 CEP = 1.25		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.477673	0.465280	0.974055	0.345852	0.332158	0.960404
0.10	0.475459	0.463113	0.974033	0.344670	0.331025	0.960412
0.25	0.463995	0.451899	0.973930	0.338526	0.325144	0.960469
0.50	0.425179	0.414020	0.973755	0.317451	0.304979	0.960712
0.75	0.367325	0.357812	0.974102	0.285160	0.274111	0.961254
1.00	0.298912	0.291704	0.975886	0.245322	0.236073	0.962299
1.25	0.228840	0.224328	0.980282	0.202068	0.194818	0.964122
1.50	0.164591	0.162734	0.988715	0.159301	0.154055	0.967067
1.75	0.111048	0.111359	1.002799	0.120151	0.116730	0.960664
2.00	0.070169	0.071883	1.024426	0.086662	0.084753	0.977971
2.50	0.022867	0.025141	1.099460	0.039354	0.039308	0.998841
3.00	0.005623	0.006962	1.238217	0.014859	0.015370	1.034375
4.00	0.000139	0.000265	1.906975	0.001198	0.001408	1.175246

Table D-6. OFFCOV

OFFSET	TAR = .40 CEP = 1.50 NUM. INT.	TACWAR	RATIO	TAR = .4 CEP = 1.175 NUM. INT.	TACWAR	RATIO
0.00	0.257879	0.250119	0.969909	0.379940	0.364706	0.959903
0.10	0.257216	0.249480	0.969923	0.378518	0.363343	0.959910
0.25	0.253766	0.246150	0.969987	0.371139	0.356274	0.959947
0.50	0.241815	0.234616	0.970228	0.345917	0.332130	0.960143
0.75	0.223125	0.216581	0.970670	0.307564	0.295471	0.960680
1.00	0.199345	0.193637	0.971364	0.260787	0.250844	0.961873
1.25	0.172432	0.167672	0.972394	0.210783	0.203224	0.964140
1.50	0.144392	0.140617	0.973856	0.162315	0.157120	0.967992
1.75	0.117039	0.114214	0.975866	0.119014	0.115922	0.974024
2.00	0.091818	0.089848	0.978545	0.083038	0.081618	0.982903
2.50	0.051200	0.050513	0.986574	0.034733	0.035162	1.012356
3.00	0.025003	0.024987	0.999353	0.011812	0.012563	1.063582
4.00	0.003982	0.004165	1.045906	0.000718	0.000915	1.274087

OFFSET	TAR = .40 CEP = 2.0 NUM. INT.	TACWAR	RATIO	TAR = .40 CEP = 4.0 NUM. INT.	TACWAR	RATIO
0.00	0.156162	0.153256	0.981394	0.042045	0.039990	0.951127
0.10	0.155917	0.153018	0.981406	0.042027	0.039973	0.951129
0.25	0.154642	0.151771	0.981437	0.041934	0.039885	0.951131
0.50	0.150169	0.147402	0.981572	0.041603	0.039571	0.951150
0.75	0.143001	0.140397	0.981789	0.041058	0.039053	0.951159
1.00	0.133535	0.131146	0.982107	0.040306	0.038339	0.951197
1.25	0.122277	0.120141	0.982534	0.039360	0.037440	0.951230
1.50	0.109796	0.107938	0.983075	0.038234	0.036371	0.951267
1.75	0.096674	0.095103	0.983752	0.036944	0.035146	0.951328
2.00	0.083465	0.082179	0.984590	0.035510	0.033784	0.951387
2.50	0.058654	0.057879	0.986771	0.032291	0.030726	0.951541
3.00	0.038096	0.037708	0.989820	0.028751	0.027362	0.951703
4.00	0.012678	0.012670	0.999382	0.021393	0.020369	0.952155

Table D-7. OFFCOV

OFFSET	TAR = .40 CEP = 8.0 NUM. INT.	TACWAR	RATIO	TAR = .60 CEP = .01 NUM. INT.	TACWAR	RATIO
0.00	0.010713	0.010000	0.933445	1.000000	1.000000	1.000000
0.10	0.010712	0.009999	0.933432	1.000000	1.000000	1.000000
0.25	0.010706	0.009993	0.933428	1.000000	1.000000	1.000000
0.50	0.010684	0.009973	0.933465	0.942120	0.976367	1.036351
0.75	0.010648	0.009940	0.933478	0.697497	0.739311	1.059949
1.00	0.010598	0.009893	0.933479	0.435728	0.501980	1.152048
1.25	0.010534	0.009833	0.933485	0.202011	0.264690	1.310275
1.50	0.010457	0.009761	0.933430	0.031967	0.084115	2.631320
1.75	0.010366	0.009676	0.933431	0.000000	0.000000	
2.00	0.010262	0.009579	0.933430	0.000000	0.000000	
2.50	0.010016	0.009350	0.933487	0.000000	0.000000	
3.00	0.009724	0.009077	0.933493	0.000000	0.000000	
4.00	0.009018	0.008419	0.933565	0.000000	0.000000	

OFFSET	TAR = .60 CEP = .10 NUM. INT.	TACWAR	RATIO	TAR = .60 CEP = .20 NUM. INT.	TACWAR	RATIO
0.00	1.000000	1.000000	1.000000	0.997776	1.000000	1.00222[illegible]
0.10	0.999998	1.000000	1.000002	0.996033	0.998872	1.002850
0.25	0.999181	1.000000	1.000820	0.982179	0.991861	1.009857
0.50	[illegible]25321	0.971042	1.049411	0.883862	0.950538	1.075437
0.75	[illegible]691813	0.744428	1.076054	0.673392	0.737807	1.095657
1.00	0.433748	0.515203	1.187792	0.427851	0.520196	1.215835
1.25	0.203162	0.286376	1.409596	0.207867	0.303331	1.459257
1.50	0.039902	0.091154	2.284448	0.058641	0.098975	1.687808
1.75	0.000294	0.000000		0.006050	0.000000	
2.00	0.000000	0.000000		0.000139	0.000000	
2.50	0.000000	0.000000		0.000000	0.000000	
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-8. OFFCOV

	TAR = .60 CEP = .40			TAR = .60 CEP = .60		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.919403	0.930085	1.011619	0.757688	0.789565	1.042072
0.10	0.912840	0.927751	1.016334	0.753116	0.786636	1.044509
0.25	0.882753	0.915700	1.037323	0.728531	0.771519	1.059006
0.50	0.772598	0.863464	1.117611	0.641483	0.714968	1.114555
0.75	0.602063	0.685704	1.138924	0.516233	0.581786	1.126984
1.00	0.406080	0.499557	1.230194	0.375313	0.438083	1.167247
1.25	0.228477	0.314693	1.377349	0.242082	0.295988	1.222677
1.50	0.101996	0.114616	1.112373	0.138347	0.144487	1.044379
1.75	0.033887	0.037643	1.110846	0.067253	0.071020	1.056015
2.00	0.007774	0.008893	1.143980	0.028709	0.029727	1.035460
2.50	0.000116	0.000185	1.592804	0.002981	0.003216	1.078887
3.00	0.000000	0.000001	0.000000	0.000120	0.000183	1.524777
4.00	0.000000	0.000000		0.000000	0.000000	

	TAR = .60 CEP = .80			TAR = .60 CEP = 1.0		
0.00	0.594646	0.578670	0.973134	0.464832	0.437920	0.942104
0.10	0.591147	0.575529	0.973580	0.462762	0.436021	0.942214
0.25	0.573306	0.559316	0.975597	0.452040	0.426183	0.942800
0.50	0.516540	0.505051	0.977757	0.415666	0.392826	0.945053
0.75	0.432688	0.426054	0.984669	0.361235	0.342932	0.943326
1.00	0.335786	0.335774	0.999964	0.296472	0.283543	0.956390
1.25	0.240906	0.247218	1.026203	0.229568	0.222040	0.967210
1.50	0.159573	0.170046	1.065632	0.167527	0.164683	0.983023
1.75	0.095681	0.109271	1.142033	0.115075	0.115683	1.005280
2.00	0.053506	0.065599	1.226003	0.074303	0.076964	1.035819
2.50	0.012092	0.019277	1.594158	0.025579	0.289430	1.131516
3.00	0.001728	0.004315	2.497062	0.006747	0.008758	1.298073
4.00	0.000003	0.000096	31.853867	0.000199	0.000418	2.099540

Table D-9. OFFCOV

OFFSET	TAR = .60 CEP = 1.250 NUM. INT.	TACWAR	RATIO	TAR = .60 CEP = 1.50 NUM. INT.	TACWAR	RATIO
0.00	0.340403	0.320031	0.940152	0.255857	0.244744	0.956498
0.10	0.339275	0.318992	0.940217	0.255215	0.244140	0.956606
0.25	0.333413	0.313594	0.940558	0.251873	0.240995	0.956811
0.50	0.313281	0.295051	0.941810	0.240287	0.230088	0.957556
0.75	0.282358	0.266551	0.944016	0.222141	0.212997	0.958836
1.00	0.244061	0.231214	0.947363	0.199002	0.191180	0.960694
1.25	0.202267	0.192576	0.952089	0.172735	0.166380	0.963215
1.50	0.160676	0.154008	0.958501	0.145265	0.140396	0.966484
1.75	0.122298	0.118260	0.966981	0.118347	0.114868	0.970604
2.00	0.089159	0.871935	0.977955	0.093392	0.091124	0.975719
2.50	0.041566	0.041960	1.009481	0.052825	0.052273	0.989552
3.00	0.016220	0.017163	1.058155	0.026257	0.026503	1.009351
4.00	0.001425	0.001763	1.237506	0.004377	0.004703	1.074545

OFFSET	TAR = .60 CEP = 1.175 NUM. INT.	TACWAR	RATIO	TAR = .60 CEP = 2.0 NUM. INT.	TACWAR	RATIO
0.00	0.372824	0.349226	0.936705	0.156417	0.152200	0.973043
0.10	0.371476	0.347991	0.936778	0.156176	0.151968	0.973059
0.25	0.364474	0.341577	0.937178	0.154917	0.150756	0.973140
0.50	0.340509	0.319621	0.938658	0.150502	0.146504	0.973437
0.75	0.303960	0.286120	0.941307	0.143421	0.139683	0.973935
1.00	0.259186	0.245033	0.945393	0.134062	0.130662	0.974645
1.25	0.211035	0.200754	0.951285	0.122919	0.119916	0.975573
1.50	0.164004	0.157352	0.959437	0.110548	0.107975	0.976723
1.75	0.121588	0.117989	0.970400	0.097519	0.095386	0.978124
2.00	0.085945	0.084640	0.984819	0.084378	0.082672	0.979786
2.50	0.037127	0.038137	1.027192	0.059605	0.058650	0.983976
3.00	0.013151	0.014393	1.094476	0.038962	0.038552	0.989465
4.00	0.000889	0.001205	1.355460	0.013179	0.013249	1.005338

Table D-10 OFFCOV

OFFSET	TAR = .60 CEP = 4.0 NUM. INT.	TACWAR	RATIO	TAR = .60 CEP = 8.0 NUM. INT.	TACWAR	RATIO
0.00	0.042572	0.039988	0.939312	0.010880	0.010000	0.919118
0.10	0.042554	0.039972	0.939315	0.010879	0.009999	0.919103
0.25	0.042460	0.039884	0.939324	0.010872	0.009993	0.919177
0.50	0.042127	0.039571	0.939335	0.010851	0.009973	0.919103
0.75	0.041577	0.039056	0.939371	0.010814	0.009940	0.919157
1.00	0.040819	0.038346	0.939422	0.010763	0.009893	0.919182
1.25	0.039864	0.037452	0.939503	0.010699	0.009833	0.919110
1.50	0.038728	0.036388	0.939581	0.010620	0.009761	0.919134
1.75	0.037427	0.035170	0.939675	0.010527	0.009676	0.919197
2.00	0.035980	0.033813	0.939786	0.010422	0.009579	0.919154
2.50	0.032731	0.030770	0.940061	0.010173	0.009351	0.919166
3.00	0.029156	0.027418	0.940388	0.009876	0.009078	0.919248
4.00	0.021720	0.020444	0.941236	0.009160	0.008421	0.919311

OFFSET	TAR = .80 CEP = .010 NUM. INT.	TACWAR	RATIO	TAR = .80 CEP = .10 NUM. INT.	TACWAR	RATIO
0.00	1.000000	0.999984	0.999984	0.999269	0.993155	0.993881
0.10	1.000000	0.999924	0.999924	0.996456	0.992513	0.996043
0.25	0.980875	0.999612	1.019103	0.961084	0.989203	1.029257
0.50	0.801742	0.857492	1.069536	0.795411	0.853123	1.072556
0.75	0.603665	0.679602	1.125793	0.600416	0.680743	1.133786
1.00	0.413668	0.501450	1.212204	0.412119	0.506059	1.227945
1.25	0.242177	0.323278	1.334884	0.242017	0.331728	1.370680
1.50	0.099990	0.186453	1.864713	0.101519	0.177026	1.743776
1.75	0.007030	0.031951	4.545013	0.013539	0.038264	2.826237
2.00	0.000000	0.000000		0.000033	0.000000	
2.50	0.000000	0.000000		0.000000	0.000000	
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-11 OFFCOV

OFFSET	TAR = .80 CEP = .20 NUM. INT.	TACWAR	RATIO	TAR = .80 CEP = .40 NUM. INT.	TACWAR	RATIO
0.00	0.972669	0.971457	0.998754	0.841991	0.883506	1.049305
0.10	0.964290	0.970255	1.006186	0.835208	0.881424	1.055335
0.25	0.960572	0.964050	1.003621	0.802179	0.870679	1.085392
0.50	0.774724	0.836140	1.079275	0.694713	0.763287	1.098708
0.75	0.590380	0.671980	1.138215	0.547345	0.621647	1.135751
1.00	0.407453	0.503501	1.235727	0.389272	0.472530	1.213880
1.25	0.241742	0.335682	1.388596	0.243814	0.324555	1.331158
1.50	0.107156	0.166553	1.555753	0.128579	0.145605	1.132420
1.75	0.025705	0.045279	1.761480	0.053840	0.059308	1.101554
2.00	0.001958	0.000000		0.016809	0.017871	1.063181
2.50	0.000000	0.000000		0.000513	0.000657	1.280632
3.00	0.000000	0.000000		0.000001	0.000007	7.233603
4.00	0.000000	0.000000		0.000000	0.000000	

OFFSET	TAR = .80 CEP = .60 NUM. INT.	TACWAR	RATIO	TAR = .80 CEP = .80 NUM. INT.	TACWAR	RATIO
0.00	0.690511	0.736146	1.066088	0.548009	0.529377	0.966001
0.10	0.685592	0.733507	1.069888	0.544886	0.526504	0.966264
0.25	0.662851	0.719886	1.086045	0.529965	0.511671	0.965482
0.50	0.588611	0.638583	1.084899	0.481321	0.462029	0.959918
0.75	0.481144	0.527575	1.096501	0.408041	0.389762	0.955202
1.00	0.360591	0.407086	1.128942	0.323814	0.307172	0.948605
1.25	0.245953	0.288047	1.117115	0.238767	0.226160	0.947198
1.50	0.150026	0.159589	1.063743	0.163204	0.155561	0.953169
1.75	0.081503	0.086990	1.067321	0.103572	0.099963	0.965153
2.00	0.038098	0.040774	1.070227	0.059566	0.060011	1.007465
2.50	0.005333	0.005695	1.067968	0.015219	0.017635	1.158718
3.00	0.000349	0.004350	1.246328	0.002650	0.003947	1.489571
4.00	0.000000			0.000016	0.000087	5.463835

Table D-12 OFFCOV

OFFSET	TAR = .8 CEP = 1.0 NUM. INT.	TACWAR	RATIO	TAR = .80 CEP = 1.25 NUM. INT.	TACWAR	RATIO
0.00	0.429764	0.410560	0.955315	0.319004	0.307904	0.965203
0.10	0.428247	0.408779	0.954541	0.318003	0.306904	0.965099
0.25	0.418843	0.399556	0.953953	0.312802	0.301711	0.964543
0.50	0.387451	0.368284	0.950530	0.294897	0.283871	0.962610
0.75	0.339630	0.321507	0.946638	0.267268	0.256450	0.959524
1.00	0.282606	0.265828	0.940631	0.232817	0.222453	0.955484
1.25	0.222546	0.208168	0.935393	0.194875	0.185279	0.950758
1.50	0.166046	0.154394	0.929827	0.156687	0.148172	0.945658
1.75	0.116605	0.108455	0.930107	0.120972	0.113779	0.940537
2.00	0.076813	0.072156	0.939372	0.089645	0.083889	0.935797
2.50	0.028399	0.027135	0.955483	0.043448	0.040370	0.929159
3.00	0.008148	0.008211	1.007722	0.017765	0.016513	0.929519
4.00	0.000264	0.000392	1.483731	0.001748	0.001697	0.970609

OFFSET	TAR = .80 CEP = 1.50 NUM. INT.	TACWAR	RATIO	TAR = .80 CEP = 1.175 NUM. INT.	TACWAR	RATIO
0.00	0.242981	0.239369	0.985134	0.347601	0.333746	0.960142
0.10	0.242396	0.238778	0.985074	0.346418	0.332566	0.960013
0.25	0.239348	0.235702	0.984767	0.340270	0.326437	0.959346
0.50	0.228768	0.225035	0.983683	0.319171	0.305454	0.957023
0.75	0.212157	0.208319	0.981909	0.286815	0.273437	0.953357
1.00	0.190891	0.136981	0.979519	0.246849	0.234171	0.948643
1.25	0.166628	0.162727	0.976587	0.203397	0.191856	0.943258
1.50	0.141090	0.137313	0.973229	0.160378	0.150377	0.937640
1.75	0.115873	0.112345	0.969556	0.120948	0.112759	0.932294
2.00	0.092288	0.089123	0.965705	0.087188	0.080889	0.927748
2.50	0.053360	0.051125	0.958115	0.039466	0.036446	0.923482
3.00	0.027233	0.025920	0.951803	0.014787	0.013755	0.930240
4.00	0.004846	0.004600	0.949234	0.001144	0.001152	1.006636

Table D-13 OFFCOV

OFFSET	TAR = .80 CEP = 2.0			TAR = .80 CEP = 4.0		
	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.150860	0.151144	1.001886	0.041780	0.039987	0.957080
0.10	0.150633	0.150920	1.001905	0.041762	0.039970	0.957094
0.25	0.149448	0.149746	1.001728	0.041671	0.039883	0.957089
0.50	0.145290	0.145629	1.002334	0.041345	0.039573	0.957132
0.75	0.138615	0.139017	1.002901	0.040809	0.039061	0.957164
1.00	0.129781	0.130262	1.003704	0.040070	0.038356	0.957216
1.25	0.119242	0.119810	1.004763	0.039139	0.037468	0.957294
1.50	0.107514	0.108168	1.006079	0.038030	0.036410	0.957400
1.75	0.095127	0.095858	1.007687	0.036761	0.035198	0.957494
2.00	0.082593	0.083385	1.009593	0.035348	0.033851	0.957638
2.50	0.058828	0.059675	1.014402	0.032176	0.030823	0.957937
3.00	0.038840	0.039647	1.020780	0.028683	0.027487	0.958305
4.00	0.013472	0.014002	1.039320	0.021407	0.020536	0.959311
	TAR = .80 CEP = 8.0			TAR = 1.0 CEP = .01		
0.00	0.010728	0.010000	0.932140	0.993217	0.998203	1.005020
0.10	0.010727	0.009999	0.932127	0.936135	0.998158	1.066254
0.25	0.010721	0.009993	0.932124	0.841171	0.927388	1.102497
0.50	0.010699	0.009973	0.932164	0.684996	0.785523	1.146755
0.75	0.010664	0.009940	0.932095	0.533951	0.643260	1.204717
1.00	0.010614	0.009893	0.932103	0.390989	0.500764	1.280762
1.25	0.010550	0.009834	0.932118	0.259592	0.358208	1.379890
1.50	0.010472	0.009762	0.932163	0.144296	0.215742	1.495138
1.75	0.010381	0.009677	0.932177	0.052060	0.123901	2.379961
2.00	0.010277	0.009580	0.932192	0.000142	0.000752	5.295798
2.50	0.010032	0.009352	0.932193	0.000000	0.000000	
3.00	0.009740	0.009080	0.932239	0.000000	0.000000	
4.00	0.009035	0.008423	0.932306	0.000000	0.000000	

Table D-14 OFFCOV

	TAR = 1.0 CEP = .10			TAR = 1.0 CEP = .20		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.932229	0.976654	1.047655	0.864827	0.941363	1.088499
0.10	0.910735	0.976225	1.071909	0.853514	0.940556	1.101981
0.25	0.831961	0.911504	1.095609	0.800843	0.882803	1.102342
0.50	0.680857	0.778961	1.144089	0.667825	0.761461	1.140210
0.75	0.531594	0.642645	1.208902	0.524365	0.633015	1.207204
1.00	0.389676	0.504115	1.293678	0.385696	0.500403	1.297401
1.25	0.259086	0.365020	1.408876	0.257606	0.366726	1.423592
1.50	0.144594	0.226777	1.568368	0.145687	0.234652	1.610659
1.75	0.053558	0.114008	2.128674	0.058862	0.103015	1.750112
2.00	0.004344	0.007520	1.731131	0.011775	0.015040	1.277288
2.50	0.000000	0.000000		0.000007	0.000000	
3.00	0.000000	0.000000		0.000000	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

	TAR = 1.0 CEP = .40			TAR = 1.0 CEP = .60		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.732668	0.834945	1.139595	0.606983	0.680745	1.121522
0.10	0.727315	0.833532	1.146040	0.603432	0.678928	1.125111
0.25	0.698889	0.790498	1.131079	0.586102	0.651658	1.111851
0.50	0.610433	0.694217	1.137253	0.526035	0.583982	1.110159
0.75	0.493371	0.585502	1.186738	0.440381	0.500318	1.136102
1.00	0.369686	0.469493	1.269978	0.342777	0.407272	1.188155
1.25	0.252850	0.351622	1.390635	0.246369	0.311832	1.265711
1.50	0.152399	0.236557	1.552221	0.162105	0.220000	1.357146
1.75	0.076791	0.081030	1.055204	0.095666	0.099681	1.041967
2.00	0.030373	0.030080	0.990358	0.050286	0.051708	1.028273
2.50	0.001800	0.001807	1.003763	0.008840	0.009085	1.027754
3.00	0.000018	0.000036	9.992498	0.000751	0.000904	1.204163
4.00	0.000000	0.000000		0.000000	0.000002	

Table D-15 OFFCOV

	TAR = 1.0 CEP = .80			TAR = 1.0 CEP = 1.0		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.492702	0.478763	0.971709	0.395452	0.383200	0.969018
0.10	0.490183	0.476741	0.972583	0.393649	0.381817	0.969942
0.25	0.479558	0.466282	0.972316	0.386721	0.374637	0.968752
0.50	0.438256	0.430757	0.982890	0.359670	0.350078	0.973331
0.75	0.378690	0.377462	0.996756	0.318519	0.312672	0.981644
1.00	0.307387	0.313739	1.020665	0.270058	0.266921	0.988385
1.25	0.234622	0.247355	1.054270	0.216406	0.217795	1.006416
1.50	0.167206	0.184982	1.106311	0.164759	0.169856	1.030935
1.75	0.111174	0.131218	1.180294	0.120086	0.126615	1.054366
2.00	0.068390	0.088290	1.290985	0.081972	0.090210	1.100503
2.50	0.020182	0.034113	1.690278	0.032740	0.039986	1.221330
3.00	0.004114	0.010670	2.593528	0.009816	0.014793	1.506992
4.00	0.000040	0.000554	13.843098	0.000428	0.001177	2.749831

	TAR = 1.0 CEP = 1.25			TAR = 1.0 CEP = 1.50		
0.00	0.300062	0.295777	0.985718	0.232004	0.233994	1.008576
0.10	0.299180	0.294933	0.985804	0.231472	0.233469	1.008625
0.25	0.294593	0.290542	0.986249	0.228699	0.230731	1.008883
0.50	0.278766	0.275388	0.987882	0.219061	0.221211	1.009817
0.75	0.254215	0.251867	0.990762	0.203881	0.206211	1.011428
1.00	0.223362	0.222273	0.995125	0.184362	0.186904	1.013787
1.25	0.189033	0.189275	1.001282	0.161959	0.164712	1.016999
1.50	0.154039	0.155522	1.009626	0.138207	0.141135	1.021187
1.75	0.120813	0.123304	1.020622	0.114546	0.117583	0.026518
2.00	0.091157	0.094332	1.034825	0.092190	0.095249	1.033179
2.50	0.046112	0.049600	1.075648	0.054643	0.057450	1.051370
3.00	0.019844	0.022609	1.1393[illegible]5	0.028731	0.030969	1.077897
4.00	0.002208	0.003060	1.385914	0.005500	0.006424	1.168051

Table D-16 OFFCOV

	TAR = 1.0 CEP = 1.175			TAR = 1.0 CEP = 2.0		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.326402	0.318267	0.975076	0.146643	0.150088	1.023496
0.10	0.325013	0.317291	0.976240	0.146429	0.149872	1.023514
0.25	0.320152	0.312215	0.975209	0.145310	0.148742	1.023616
0.50	0.302122	0.294743	0.975576	0.141382	0.144773	1.023987
0.75	0.272374	0.267768	0.983089	0.135070	0.138393	1.024604
1.00	0.236960	0.234099	0.987927	0.126702	0.129931	1.025482
1.25	0.198275	0.196955	0.993343	0.116698	0.119806	1.026634
1.50	0.157639	0.159463	1.011573	0.105533	0.108497	1.028084
1.75	0.121725	0.124245	1.020706	0.093703	0.096500	1.029845
2.00	0.089389	0.093159	1.042179	0.081685	0.084296	1.031958
2.50	0.042486	0.046676	1.098762	0.058742	0.060936	1.037350
3.00	0.016439	0.020057	1.220098	0.039237	0.040985	1.044552
4.00	0.001368	0.002336	1.707834	0.014010	0.014934	1.065951
	TAR = 1.0 CEP = 4.0			TAR = 1.0 CEP = 8.0		
0.00	0.041458	0.039985	0.964476	0.010707	0.010000	0.933968
0.10	0.041441	0.039969	0.964473	0.010706	0.010000	0.934056
0.25	0.041351	0.039882	0.964478	0.010700	0.009993	0.933955
0.50	0.041031	0.039574	0.964500	0.010678	0.009973	0.934003
0.75	0.040502	0.039067	0.964564	0.010643	0.009940	0.933946
1.00	0.039774	0.038367	0.964626	0.010593	0.009894	0.933971
1.25	0.038857	0.037486	0.964710	0.010529	0.009834	0.934009
1.50	0.037765	0.036436	0.964811	0.010452	0.009762	0.933984
1.75	0.036514	0.035233	0.964928	0.010362	0.009678	0.933950
2.00	0.035122	0.033895	0.965061	0.010258	0.009581	0.934001
2.50	0.031993	0.030886	0.965408	0.010014	0.009353	0.933997
3.00	0.028545	0.027569	0.965822	0.009723	0.009082	0.934054
4.00	0.021353	0.020646	0.966893	0.009021	0.008426	0.934083

Table D-17 OFFCOV

TAR = 1.25 CEP = .0[illegible]

OFFSET	NOM. INT.	TACMAR	RATIO
0.00	0.640000	0.640000	1.000000
0.10	0.640000	0.639971	0.999954
0.25	0.639712	0.639826	1.000181
0.50	0.562722	0.560124	0.995383
0.75	0.462359	0.480564	1.039373
1.00	0.361376	0.400627	1.108614
1.25	0.264751	0.323717	1.222712
1.50	0.175696	0.240435	1.368539
1.75	0.097575	0.140728	1.442182
2.00	0.035164	0.079389	2.257644
2.50	0.000000	0.000007	
3.00	0.000000	0.000002	
4.00	0.000000	0.000000	

TAR = 1.25 CEP = .10

OFFSET	NOM. INT.	TACMAR	RATIO
0.00	0.639946	0.640000	1.000084
0.10	0.639554	0.639719	1.000255
0.25	0.630635	0.638240	1.012031
0.50	0.559091	0.563244	1.007865
0.75	0.460479	0.485437	1.054796
1.00	0.360209	0.406171	1.127582
1.25	0.264216	0.326171	1.234950
1.50	0.175527	0.248251	1.413004
1.75	0.097879	0.167238	1.708623
2.00	0.036235	0.073894	2.039247
2.50	0.000002	0.000000	
3.00	0.000000	0.000000	
4.00	0.000000	0.000000	

TAR = 1.25 CEP = .20

OFFSET	NOM. INT.	TACMAR	RATIO
0.00	0.632429	0.635268	1.004458
0.10	0.629550	0.634722	1.008144
0.25	0.612724	0.632471	1.031250
0.50	0.547199	0.562177	1.027372
0.75	0.454343	0.487375	1.072716
1.00	0.356444	0.409204	1.147374
1.25	0.262100	0.329596	1.257526
1.50	0.175036	0.251369	1.436514
1.75	0.098127	0.171959	1.752435
2.00	0.039984	0.067787	1.695357
2.50	0.000485	0.000001	
3.00	0.000000	0.000002	
4.00	0.000000	0.000000	

TAR = 1.25 CEP = .40

OFFSET	NOM. INT.	TACMAR	RATIO
0.00	0.575729	0.596497	1.036073
0.10	0.572960	0.595525	1.039384
0.25	0.556434	0.590483	1.060420
0.50	0.504124	0.533217	1.057710
0.75	0.428186	0.466854	1.090307
1.00	0.343777	0.396891	1.154476
1.25	0.254654	0.319573	1.254922
1.50	0.173768	0.245291	1.411632
1.75	0.104649	0.174142	1.664051
2.00	0.052747	0.051339	0.973312
2.50	0.006122	0.005216	0.855057
3.00	0.000165	0.000194	1.176855
4.00	0.000000	0.000000	

Table D-18 OFFCOV

	TAR = 1.25 CEP = .60			TAR = 1.25 CEP = .80		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.500350	0.523747	1.046760	0.422782	0.416998	0.986318
0.10	0.497688	0.522469	1.049792	0.420832	0.415533	0.987409
0.25	0.485707	0.515836	1.062030	0.412096	0.407929	0.989888
0.50	0.446278	0.473121	1.060149	0.383270	0.381889	0.996396
0.75	0.386866	0.418439	1.081614	0.338624	0.342130	1.010353
1.00	0.316240	0.355866	1.125303	0.284539	0.293324	1.030873
1.25	0.242599	0.289928	1.195090	0.226373	0.240660	1.063114
1.50	0.172945	0.224827	1.299992	0.170257	0.188957	1.109835
1.75	0.113292	0.163848	1.446246	0.120094	0.141979	1.182233
2.00	0.066708	0.067435	1.010901	0.079300	0.102091	1.287400
2.50	0.016024	0.015289	0.954108	0.027193	0.046261	1.701216
3 00	0.002074	0.002044	0.985544	0.006533	0.017561	2.691165
4.00	0.000002	0.000007	3.746195	0.000112	0.001498	13.376043

	TAR = 1.25 CEP = 1.0			TAR = 1.25 CEP = 1.25		
0.00	0.350726	0.349000	0.995079	0.275049	0.280618	1.020247
0.10	0.349453	0.347902	0.995532	0.274430	0.279892	1.019905
0.25	0.343196	0.342192	0.997075	0.270691	0.276114	1.020035
0.50	0.322498	0.322555	1.000176	0.257246	0.263033	1.022494
0.75	0.290736	0.292298	1.005372	0.236790	0.242592	1.024504
1.00	0.250624	0.254646	1.016048	0.210597	0.216617	1.028583
1.25	0.207241	0.213273	1.029108	0.180868	0.187264	1.035361
1.50	0.163422	0.171722	1.050768	0.150103	0.156734	1.044174
1.75	0.122654	0.132924	0.083732	0.119828	0.127004	1.059887
2.00	0.088281	0.098917	1.120478	0.093191	0.099637	1.069170
2.50	0.038122	0.048671	1.276719	0.049160	0.055650	1.132023
3.00	0.013387	0.020456	1.528071	0.022723	0.027309	1.201811
4.00	0.000732	0.002252	3.076768	0.002904	0.004460	1.535817

Table D-19 OFFCOV

	TAR = 1.25 CEP = 1.50			TAR = 1.25 CEP = 1.175		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.216147	0.227275	1.051483	0.295905	0.298917	1.010179
0.10	0.215689	0.226801	1.051517	0.295104	0.298094	1.010134
0.25	0.213297	0.224328	1.051717	0.290639	0.293813	1.010921
0.50	0.204967	0.215715	1.052437	0.275473	0.279018	1.012869
0.75	0.191786	0.202088	1.053718	0.251996	0.255997	1.015876
1.00	0.174718	0.184445	1.055673	0.222019	0.226922	1.022084
1.25	0.154947	0.164005	1.058459	0.188891	0.194339	1.028843
1.50	0.133745	0.142073	1.062263	0.154495	0.160799	1.040807
1.75	0.112339	0.119903	1.067334	0.121326	0.128543	1.059488
2.00	0.091799	0.098586	1.073932	0.092391	0.099279	1.074548
2.50	0.056387	0.061628	1.092940	0.046263	0.053406	1.154399
3.00	0.030924	0.034705	1.122272	0.019928	0.025031	1.256097
4.00	0.006549	0.008046	1.228654	0.002062	0.003637	1.763932
	TAR = 1.25 CEP = 2.0			TAR = 1.25 CEP = 4.0		
0.00	0.140363	0.148768	1.059884	0.040962	0.039983	0.976106
0.10	0.140167	0.148563	1.059903	0.040946	0.039967	0.976089
0.25	0.139145	0.147491	1.059982	0.040858	0.039881	0.976098
0.50	0.135553	0.143725	1.060286	0.040545	0.039577	0.976133
0.75	0.129769	0.137660	1.060810	0.040029	0.039076	0.976184
1.00	0.122082	0.129597	1.061558	0.039318	0.038384	0.976246
1.25	0.112859	0.119920	1.062567	0.038423	0.037513	0.976309
1.50	0.102522	0.109069	1.063858	0.037356	0.036475	0.976406
1.75	0.091511	0.097503	1.065481	0.036133	0.035285	0.976524
2.00	0.080260	0.085674	1.067454	0.034772	0.033960	0.976647
2.50	0.058554	0.062811	1.072707	0.031710	0.030980	0.976975
3.00	0.039793	0.042980	1.080098	0.028332	0.027690	0.977352
4.00	0.014827	0.016363	1.103587	0.021268	0.020808	0.978379

Table D-20 OFFCOV

OFFSET	TAR = 1.25 CEP = 8.0 NUM. INT.	TACWAR	RATIO	TAR = 1.50 CEP = .01 NUM. INT.	TACWAR	RATIO
0.00	0.010674	0.010000	0.936856	0.444444	0.444444	1.000001
0.10	0.010673	0.009999	0.936844	0.444444	0.444428	0.999965
0.25	0.010667	0.009993	0.936846	0.444444	0.444345	0.999777
0.50	0.010646	0.009973	0.936818	0.444289	0.444057	0.999478
0.75	0.010610	0.009940	0.936868	0.397123	0.388749	0.978914
1.00	0.010561	0.009894	0.936832	0.329633	0.333327	1.011207
1.25	0.010497	0.009835	0.936904	0.259087	0.277841	1.072386
1.50	0.010421	0.009763	0.936840	0.190418	0.222343	1.167656
1.75	0.010331	0.009679	0.936846	0.126598	0.166875	1.318146
2.00	0.010228	0.009582	0.936863	0.070377	0.110487	1.569925
2.50	0.009985	0.009355	0.936901	0.000069	0.000338	4.893869
3.00	0.009696	0.009084	0.936931	0.000000	0.000000	
4.00	0.008998	0.008431	0.936959	0.000000	0.000000	

OFFSET	TAR = 1.50 CEP = 0.10 NUM. INT.	TACWAR	RATIO	TAR = 1.50 CEP = 0.20 NUM. INT.	TACWAR	RATIO
0.00	0.444444	0.444444	1.000001	0.444363	0.444444	1.000183
0.10	0.444444	0.444284	0.999640	0.444264	0.444124	0.999684
0.25	0.444440	0.443449	0.997771	0.443204	0.442454	0.998308
0.50	0.439488	0.440570	1.002461	0.430340	0.436695	1.014767
0.75	0.395032	0.387493	0.980915	0.388153	0.386097	0.994702
1.00	0.328481	0.333270	1.014580	0.324891	0.333207	1.025598
1.25	0.258398	0.278413	1.077459	0.256294	0.279049	1.088784
1.50	0.190061	0.223427	1.175555	0.188985	0.224632	1.188624
1.75	0.126537	0.168747	1.333577	0.126376	0.170827	1.351737
2.00	0.070643	0.104866	1.484448	0.071537	0.098621	1.378596
2.50	0.002130	0.003377	1.585338	0.005817	0.006754	1.161080
3.00	0.000000	0.000000		0.000004	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-21 OFFCOV

	TAR = 1.50 CEP = 0.40			TAR = 1.50 CEP = 0.60		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.433095	0.444444	1.031313	0.398332	0.414500	1.040590
0.10	0.432120	0.443803	1.027036	0.397318	0.413624	1.041041
0.25	0.426287	0.440464	1.033257	0.390995	0.409066	1.046218
0.50	0.403926	0.428945	1.061940	0.368287	0.393340	1.068026
0.75	0.363938	0.383305	1.053214	0.332377	0.355064	1.068256
1.00	0.309420	0.333082	1.076471	0.285494	0.310532	1.087699
1.25	0.247457	0.280320	1.132803	0.232551	0.262534	1.128929
1.50	0.184775	0.227042	1.228747	0.178188	0.213830	1.200026
1.75	0.126293	0.174988	1.385568	0.127032	0.166798	1.313037
2.00	0.076185	0.081930	1.075402	0.083273	0.088999	1.068765
2.50	0.015265	0.012848	0.841686	0.025813	0.025251	0.978227
3.00	0.000912	0.000813	0.890942	0.004556	0.004380	0.961329
4.00	0.000000	0.000000		0.000015	0.000030	2.007140

	TAR = 1.50 CEP = 0.80			TAR = 1.50 CEP = 1.0		
0.00	0.351796	0.359660	1.022353	0.303530	0.314800	1.037130
0.10	0.350929	0.358621	1.021919	0.302648	0.313947	1.037335
0.25	0.345722	0.353217	1.021680	0.298075	0.309508	1.038356
0.50	0.326198	0.334574	1.025679	0.282997	0.294160	1.039445
0.75	0.296534	0.305664	1.030789	0.259751	0.270252	1.040428
1.00	0.257802	0.269337	1.044745	0.229310	0.240010	1.046663
1.25	0.214505	0.228902	1.067116	0.194870	0.206046	1.057352
1.50	0.169546	0.187630	1.106662	0.159522	0.170991	1.071897
1.75	0.127058	0.148339	1.167493	0.124752	0.137169	1.099536
2.00	0.089458	0.113113	1.264421	0.093121	0.106369	1.142267
2.50	0.036137	0.059010	1.632939	0.045132	0.057777	1.280175
3.00	0.010624	0.026640	2.507537	0.017749	0.927403	1.543890
4.00	0.000286	0.003519	12.302786	0.001272	0.004104	3.226031

Table D-22 OFFCOV

	TAR = 1.50 CEP = 1.25			TAR = 1.50 CEP = 1.50		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.247938	0.265459	1.070668	0.201350	0.220556	1.095386
0.10	0.247347	0.264844	1.070740	0.200960	0.220132	1.095404
0.25	0.243741	0.261639	1.073432	0.198924	0.217922	1.095505
0.50	0.233020	0.250506	1.075042	0.191814	0.210209	1.095898
0.75	0.217067	0.232994	1.073373	0.180505	0.197954	1.096670
1.00	0.195736	0.210514	1.075499	0.165746	0.181989	1.098001
1.25	0.170773	0.184768	1.081953	0.148474	0.163340	1.100125
1.50	0.144777	0.157538	1.088141	0.129719	0.143122	1.103320
1.75	0.118830	0.130482	1.098060	0.110503	0.122429	1.107922
2.00	0.094008	0.104986	1.116773	0.091755	0.102242	1.114289
2.50	0.053435	0.062304	1.165979	0.058505	0.066346	1.134020
3.00	0.026250	0.032926	1.254340	0.033528	0.039108	1.166423
4.00	0.003963	0.006494	1.638708	0.007882	0.010185	1.292165

	TAR = 1.50 CEP = 1.175			TAR = 1.50 CEP = 2.0		
0.00	0.263910	0.279567	1.059329	0.134663	0.147448	1.094944
0.10	0.263125	0.278885	1.059897	0.134485	0.147255	1.094957
0.25	0.259094	0.275331	1.062669	0.133555	0.146245	1.095018
0.50	0.247242	0.263003	1.063749	0.130287	0.142694	1.095227
0.75	0.229455	0.243671	1.061957	0.125015	0.136965	1.095592
1.00	0.205335	0.218970	1.066405	0.117986	0.129330	1.096147
1.25	0.177812	0.190855	1.073352	0.109521	0.120135	1.096914
1.50	0.149489	0.161346	1.079318	0.099986	0.109780	1.097953
1.75	0.120943	0.132297	1.093882	0.089770	0.098687	1.099328
2.00	0.094124	0.105216	1.117844	0.079261	0.087272	1.101075
2.50	0.051362	0.060723	1.182256	0.058747	0.064977	1.106046
3.00	0.023835	0.031015	1.301247	0.040687	0.045308	1.113565
4.00	0.003001	0.005609	1.868959	0.015878	0.018096	1.139694

Table D-23 OFFCOV

OFFSET	TAR = 1.50 CEP = 4.0 NUM. INT.	TACWAR	RATIO	TAR = 1.50 CEP = 8.0 NUM. INT.	TACWAR	RATIO
0.00	0.040740	0.039981	0.981377	0.010727	0.010000	0.932227
0.10	0.040723	0.039965	0.981392	0.010726	0.009999	0.932221
0.25	0.040637	0.039881	0.981392	0.010720	0.009993	0.932216
0.50	0.040330	0.039581	0.981428	0.010699	0.009973	0.932186
0.75	0.039825	0.039086	0.981449	0.010663	0.009940	0.932231
1.00	0.039127	0.038404	0.981519	0.010614	0.009894	0.932189
1.25	0.038249	0.037544	0.981571	0.010550	0.009835	0.932253
1.50	0.037202	0.036519	0.981650	0.010474	0.009764	0.932180
1.75	0.036001	0.035344	0.981759	0.010383	0.009680	0.932263
2.00	0.034664	0.034035	0.981864	0.010280	0.009584	0.932266
2.50	0.031653	0.031088	0.982158	0.010037	0.009357	0.932269
3.00	0.028326	0.027831	0.982509	0.009748	0.009088	0.932253
4.00	0.021349	0.020997	0.999983	0.009048	0.008436	0.932351

OFFSET	TAR = 1.75 CEP = 0.01 NUM. INT.	TACWAR	RATIO	TAR = 1.75 CEP = 0.10 NUM. INT.	TACWAR	RATIO
0.00	0.326531	0.326531	0.999999	0.326531	0.326531	0.999999
0.10	0.326531	0.326521	0.999969	0.326531	0.326434	0.999704
0.25	0.326531	0.[illegible]26471	0.[illegible]	0.326531	0.325933	0.998169
0.50	0.326531	0.326297	0.999283	0.326528	0.324193	0.992849
0.75	0.326430	0.326023	0.[illegible]98754	0.323339	0.321459	0.994184
1.00	0.294268	0.285367	0.969751	0.292890	0.282239	0.963636
1.25	0.246043	0.244660	0.994379	0.245281	0.242519	0.988739
1.50	0.194336	0.203931	1.049374	0.193886	0.202578	1.044829
1.75	0.143299	0.163206	1.138922	0.143078	0.162676	1.136976
2.00	0.095484	0.122507	1.283011	0.095472	0.123030	1.288648
2.50	0.019187	0.040456	2.108519	0.019807	0.037215	1.878857
3.00	0.000000	0.000000		0.000001	0.000000	
4.00	0.000000	0.000000		0.000000	0.000000	

Table D-24 OFFCOV

OFFSET	TAR = 1.75 CEP = .20 NUM. INT.	TACWAR	RATIO	TAR = 1.75 CEP = .40 NUM. INT.	TACWAR	RATIO
0.00	0.326531	0.326531	0.999999	0.325167	0.326531	1.004194
0.10	0.326530	0.326338	0.999413	0.324946	0.326146	1.003693
0.25	0.326520	0.325336	0.996374	0.323641	0.324141	1.001545
0.50	0.325847	0.321856	0.987751	0.317122	0.317181	1.000185
0.75	0.317508	0.316387	0.996468	0.301090	0.306242	1.017113
1.00	0.288335	0.278764	0.966807	0.272394	0.271814	0.997872
1.25	0.242902	0.240140	0.988628	0.232589	0.235381	1.012005
1.50	0.192509	0.201074	1.044490	0.186694	0.198066	1.060912
1.75	0.142412	0.162087	1.138158	0.139814	0.160909	1.150881
2.00	0.095454	0.123611	1.294976	0.094793	0.124772	1.316260
2.50	0.021953	0.033613	1.531122	0.029305	0.025757	0.878931
3.00	0.000269	0.000000		0.003419	0.002555	0.747308
4.00	0.000000	0.000000		0.000000	0.000002	0.000000

OFFSET	TAR = 1.75 CEP = .60 NUM. INT.	TACWAR	RATIO	TAR = 1.75 CEP = .80 NUM. INT.	TACWAR	RATIO
0.00	0.313301	0.326531	1.042227	0.289464	0.308039	1.064171
0.10	0.312835	0.325954	1.041935	0.288811	0.307313	1.064064
0.25	0.309924	0.322946	1.042018	0.285509	0.303531	1.063122
0.50	0.299219	0.312506	1.044404	0.274280	0.290398	1.058765
0.75	0.279945	0.296098	1.057702	0.255209	0.269761	1.057019
1.00	0.252258	0.264864	1.049974	0.230033	0.243309	1.057712
1.25	0.216827	0.230623	1.063626	0.199081	0.213074	1.070288
1.50	0.176896	0.195058	1.102671	0.165281	0.181174	1.096160
1.75	0.135786	0.159731	1.176346	0.130583	0.149574	1.145436
2.00	0.096984	0.125934	1.298501	0.097886	0.119898	1.224874
2.50	0.037595	0.037737	1.003778	0.045536	0.070518	1.548632
3.00	0.009086	0.008242	0.907154	0.015643	0.036861	2.356403
4.00	0.000073	0.000099	1.356649	0.000617	0.007070	11.458959

Table D-25 OFFCOV

	TAR = 1.75 CEP = 1.0			TAR = 1.75 CEP = 1.25		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.258396	0.280600	1.085930	0.218035	0.250301	1.147983
0.10	0.257745	0.279952	1.086158	0.217739	0.249786	1.147180
0.25	0.255078	0.276574	1.084271	0.215887	0.247101	1.144585
0.50	0.244827	0.264838	1.081737	0.207820	0.237746	1.144000
0.75	0.228233	0.246376	1.079492	0.195024	0.222935	1.143115
1.00	0.206862	0.222670	1.076417	0.178574	0.203736	1.140907
1.25	0.181054	0.195511	1.079849	0.159205	0.181462	1.139799
1.50	0.152913	0.166774	1.090646	0.137878	0.157517	1.142437
1.75	0.124758	0.138207	1.107804	0.115837	0.133259	1.150398
2.00	0.097339	0.111271	1.143128	0.094614	0.109873	1.161272
2.50	0.051996	0.066134	1.271898	0.057299	0.069144	1.206723
3.00	0.022349	0.035015	1.566719	0.029818	0.039258	1.316573
4.00	0.002157	0.006938	3.216722	0.005125	0.009293	1.813333

	TAR = 1.75 CEP = 1.50			TAR = 1.75 CEP = 1.175		
0.00	0.182107	0.213837	1.174238	0.229943	0.260218	1.131772
0.10	0.181802	0.213462	1.174146	0.229540	0.259660	1.131219
0.25	0.180068	0.211505	1.174583	0.227492	0.256752	1.128619
0.50	0.173987	0.204660	1.176293	0.218825	0.246628	1.127056
0.75	0.164866	0.193740	1.175135	0.204723	0.230635	1.126569
1.00	0.152996	0.179424	1.172736	0.186887	0.209971	1.123518
1.25	0.138961	0.162561	1.169833	0.165698	0.186100	1.123128
1.50	0.122882	0.144088	1.172572	0.142267	0.160578	1.128710
1.75	0.106087	0.124943	1.177745	0.118679	0.134890	1.136595
2.00	0.089587	0.105992	1.183119	0.095714	0.110313	1.152523
2.50	0.059846	0.071420	1.193392	0.056005	0.068073	1.215480
3.00	0.035422	0.044082	1.244483	0.027735	0.037734	1.360526
4.00	0.009114	0.012908	1.416240	0.004175	0.008404	2.012948

Table D-26 OFFCOV

	TAR = 1.75 CEP = 2.0			TAR = 1.75 CEP = 4.0		
OFFSET	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.127408	0.146129	1.146934	0.040189	0.039979	0.994783
0.10	0.127251	0.145948	1.146927	0.040173	0.039964	0.994785
0.25	0.126427	0.145002	1.146920	0.040089	0.039880	0.994798
0.50	0.123527	0.141673	1.146900	0.039792	0.039585	0.994806
0.75	0.118838	0.136294	1.146893	0.039301	0.039098	0.994842
1.00	0.112564	0.129106	1.146954	0.038625	0.038426	0.994860
1.25	0.104974	0.120417	1.147115	0.037772	0.037580	0.994907
1.50	0.096375	0.110588	1.147477	0.036755	0.036570	0.994964
1.75	0.087100	0.100001	1.148117	0.035589	0.035412	0.995013
2.00	0.077483	0.089038	1.149133	0.034289	0.034120	0.995084
2.50	0.058454	0.067383	1.152752	0.031359	0.031211	0.995269
3.00	0.041343	0.047932	1.159383	0.028116	0.027989	0.995484
4.00	0.016975	0.020142	1.186567	0.021292	0.021211	0.996172

	TAR = 1.75 CEP = 8.0			TAR = 2.0 CEP = 0.01		
0.00	0.010714	0.010000	0.933358	0.250000	0.250000	1.000000
0.10	0.010713	0.009999	0.933347	0.250000	0.249994	0.999976
0.25	0.010707	0.009999	0.933351	0.250000	0.249963	0.999851
0.50	0.010686	0.009974	0.933855	0.250000	0.249854	0.999415
0.75	0.010650	0.009941	0.933392	0.250000	0.249681	0.998722
1.00	0.010601	0.009895	0.933373	0.249929	0.249455	0.998103
1.25	0.010538	0.009836	0.933378	0.226506	0.218332	0.963912
1.50	0.010462	0.009765	0.933341	0.190388	0.187187	0.983184
1.75	0.010372	0.009681	0.933376	0.150975	0.156034	1.033511
2.00	0.010269	0.009585	0.933427	0.111651	0.124889	1.118568
2.50	0.010027	0.009360	0.933453	0.041575	0.062033	1.492068
3.00	0.009740	0.009091	0.933384	0.000041	0.000160	3.892183
4.00	0.009043	0.008442	0.933517	0.000000	0.000000	

Table D-27 OFFCOV

OFFSET	TAR = 2.0 CEP = .10			TAR = 2.0 CEP = .2C		
	NUM. INT.	TACWAR	RATIO	NUM. INT.	TACWAR	RATIO
0.00	0.250000	0.250000	1.000000	0.250000	0.250000	1.000000
0.10	0.250000	0.249940	0.999761	0.250000	0.249880	0.999521
0.25	0.250000	0.249628	0.998511	0.250000	0.249256	0.997023
0.50	0.250000	0.248538	0.994151	0.249994	0.247076	0.988326
0.75	0.249998	0.246806	0.987232	0.249546	0.243612	0.976221
1.00	0.247745	0.244549	0.987100	0.243648	0.239098	0.981327
1.25	0.225523	0.214569	0.951426	0.222269	0.210387	0.946542
1.50	0.189846	0.184365	0.971130	0.188153	0.181230	0.963206
1.75	0.150659	0.154093	1.022796	0.149694	0.151937	1.014982
2.00	0.111504	0.123892	1.111098	0.111063	0.122784	1.105533
2.50	0.041765	0.057827	1.384582	0.042390	0.053154	1.253931
3.00	0.001267	0.001596	1.259507	0.003474	0.003192	0.918708
4.00	0.000000	0.000000		0.000000	0.000000	

OFFSET	TAR = 2.0 CEP = .40			TAR = 2.0 CEP = .60		
0.00	0.249895	0.250000	1.000420	0.246807	0.250000	1.012937
0.10	0.249866	0.249761	0.999578	0.246569	0.249641	1.012459
0.25	0.249684	0.248511	0.995304	0.245519	0.247767	1.009157
0.50	0.248418	0.244151	0.982825	0.241195	0.241227	1.000133
0.75	0.243829	0.237224	0.972911	0.232571	0.230836	0.992539
1.00	0.232230	0.228197	0.982633	0.217866	0.217295	0.997380
1.25	0.210908	0.202024	0.957878	0.196739	0.193661	0.984356
1.50	0.180777	0.174960	0.967824	0.169531	0.168690	0.995042
1.75	0.145596	0.147624	1.013925	0.138663	0.143310	1.033515
2.00	0.109344	0.120568	1.102645	0.106692	0.118351	1.109282
2.50	0.045496	0.043808	0.962904	0.050257	0.051825	1.031201
3.00	0.009193	0.006383	0.694352	0.015688	0.013891	0.885483
4.00	0.000005	0.000014	2.786208	0.000238	0.000275	1.153469

Table D-28 OFFCOV

OFFSET	TAR = 2.0 CEP = .80 NUM. INT.	TACWAR	RATIO	TAR = 2.0 CEP = 1.0 NUM. INT.	TACWAR	RATIO
0.00	0.235934	0.250000	1.059618	0.218671	0.246400	1.126807
0.10	0.235666	0.249521	1.058792	0.218186	0.245918	1.127102
0.25	0.234002	0.247023	1.055645	0.216193	0.243402	1.125857
0.50	0.227732	0.238303	1.046417	0.209688	0.234627	1.118933
0.75	0.217219	0.224448	1.033279	0.199066	0.220698	1.108668
1.00	0.201455	0.206394	1.024514	0.184027	0.202576	1.100796
1.25	0.181422	0.185298	1.021366	0.165872	0.181446	1.093889
1.50	0.157089	0.162421	1.033940	0.144858	0.158589	1.094789
1.75	0.130545	0.138997	1.064744	0.122175	0.135260	1.107097
2.00	0.103294	0.116135	1.124318	0.099609	0.112572	1.130141
2.50	0.054714	0.075451	1.379008	0.057938	0.072454	1.250547
3.00	0.022209	0.044539	2.005467	0.028115	0.042283	1.503944
4.00	0.001341	0.011642	8.681769	0.003299	0.010735	3.254025

OFFSET	TAR = 2.0 CEP = 1.25 NUM. INT.	TACWAR	RATIO	TAR = 2.0 CEP = 1.50 NUM. INT.	TACWAR	RATIO
0.00	0.190864	0.235142	1.231986	0.163312	0.207118	1.268235
0.10	0.190654	0.234716	1.231109	0.163092	0.206789	1.267928
0.25	0.189161	0.232492	1.229068	0.161967	0.205069	1.266118
0.50	0.183683	0.224719	1.223409	0.158067	0.199044	1.259237
0.75	0.174121	0.212339	1.219498	0.150329	0.189392	1.259851
1.00	0.161735	0.196143	1.212742	0.140434	0.176661	1.257964
1.25	0.146785	0.177122	1.182505	0.128847	0.161542	1.253748
1.50	0.130112	0.156360	1.201734	0.116393	0.144808	1.244134
1.75	0.112093	0.134938	1.200381	0.102193	0.127253	1.245224
2.0C	0.093939	0.113841	1.211866	0.087696	0.109625	1.250054
2.50	0.060219	0.075700	1.257080	0.060896	0.076645	1.258624
3.00	0.034037	0.045974	1.350711	0.038099	0.049491	1.299010
4.00	0.006930	0.012919	1.864142	0.010977	0.016255	1.480802

Table D-29 OFFCOV

OFFSET	TAR = 2.0 CEP = 1.175 NUM. INT.	TAR = 2.0 CEP = 1.175 TACWAR	TAR = 2.0 CEP = 1.175 RATIO	TAR = 2.0 CEP = 2.0 NUM. INT.	TAR = 2.0 CEP = 2.0 TACWAR	TAR = 2.0 CEP = 2.0 RATIO
0.00	0.199314	0.240868	1.208487	0.119049	0.144809	1.216377
0.10	0.199095	0.240418	1.200756	0.118913	0.144640	1.216352
0.25	0.197540	0.238069	1.205168	0.118201	0.143759	1.211623
0.50	0.191561	0.229864	1.199954	0.115690	0.140567	1.215807
0.75	0.181557	0.216814	1.194192	0.111620	0.135634	1.215140
1.00	0.168384	0.199778	1.186446	0.106152	0.128902	1.214314
1.25	0.152413	0.179828	1.179870	0.099500	0.120735	1.213417
1.50	0.134437	0.158128	1.176227	0.091916	0.111453	1.212549
1.75	0.115038	0.135834	1.180778	0.083671	0.101398	1.211870
2.00	0.095727	0.113987	1.190752	0.075046	0.090919	1.211510
2.50	0.059733	0.074832	1.252771	0.057715	0.069976	1.212446
3.00	0.032482	0.044740	1.377393	0.041758	0.050814	1.216859
4.00	0.005743	0.012080	2.103512	0.018102	0.022503	1.243109

OFFSET	TAR = 2.0 CEP = 4.0 NUM. INT.	TAR = 2.0 CEP = 4.0 TACWAR	TAR = 2.0 CEP = 4.0 RATIO	TAR = 2.0 CEP = 8.0 NUM. INT.	TAR = 2.0 CEP = 8.0 TACWAR	TAR = 2.0 CEP = 8.0 RATIO
0.00	0.039369	0.039977	1.015444	0.010647	0.009999	0.939232
0.10	0.039354	0.039962	1.015450	0.010646	0.009999	0.939221
0.25	0.039274	0.039880	1.015437	0.010640	0.009993	0.939231
0.50	0.038988	0.039590	1.015449	0.010619	0.009974	0.939231
0.75	0.038517	0.039112	1.015442	0.010584	0.009941	0.939238
1.00	0.037868	0.038452	1.015409	0.01053	0.009895	0.939177
1.25	0.037048	0.037620	1.015411	0.010473	0.009837	0.939243
1.50	0.036071	0.036626	1.015381	0.010398	0.009766	0.939189
1.75	0.034948	0.035486	1.015390	0.010309	0.009682	0.939221
2.00	0.033697	0.034215	1.015358	0.010208	0.009587	0.939189
2.50	0.030873	0.031346	1.015324	0.009969	0.009363	0.939171
3.00	0.027739	0.028165	1.015348	0.009684	0.009095	0.939195
4.00	0.021122	0.021449	1.015463	0.008995	0.008448	0.939233

Table D-30 OFFCOV

OFFSET	TAR = 4.0 CEP = .01 NUM. INT.	TACWAR	RATIO	TAR = 4.0 CEP = .10 NUM. INT.	TACWAR	RATIO
0.00	0.062500	0.062500	1.000000	0.062500	0.062500	1.000000
0.10	0.062500	0.062500	0.999995	0.062500	0.062497	0.999950
0.25	0.062500	0.062498	0.999997	0.062500	0.062481	0.999690
0.50	0.062500	0.062492	0.999876	0.062500	0.062423	0.998763
0.75	0.062500	0.062483	0.999723	0.062500	0.062327	0.997235
1.00	0.062500	0.062470	0.999513	0.062500	0.062195	0.995127
1.25	0.062500	0.062453	0.999247	0.062500	0.062029	0.992469
1.50	0.062500	0.062433	0.998930	0.062500	0.061831	0.989301
1.75	0.062500	0.062410	0.998567	0.062500	0.061604	0.985667
2.00	0.062500	0.062385	0.998162	0.062500	0.061351	0.981617
2.50	0.062500	0.062328	0.997249	0.062500	0.060781	0.972492
3.00	0.062485	0.062265	0.996478	0.062044	0.060150	0.969473
4.00	0.029589	0.032716	1.105666	0.029571	0.045905	1.552379

OFFSET	TAR = 4.0 CEP = .20 NUM. INT.	TACWAR	RATIO	TAR = 4.0 CEP = .40 NUM. INT.	TACWAR	RATIO
0.00	0.062500	0.062500	1.000000	0.062500	0.062500	1.000000
0.10	0.062500	0.062494	0.999901	0.062500	0.062494	0.999901
0.25	0.062500	0.062461	0.999379	0.062500	0.062461	0.999379
0.50	0.062500	0.062345	0.997527	0.062500	0.062345	0.997527
0.75	0.062500	0.062154	0.994470	0.062500	0.062154	0.994470
1.00	0.062500	0.061891	0.990253	0.062500	0.061891	0.990253
1.25	0.062500	0.061559	0.984939	0.062500	0.061559	0.984939
1.50	0.062500	0.061163	0.978602	0.062500	0.061163	0.978602
1.75	0.062500	0.060708	0.971334	0.062500	0.060708	0.971334
2.00	0.062500	0.060202	0.963234	0.062497	0.060202	0.963278
2.50	0.062499	0.059061	0.944998	0.062258	0.059061	0.948656
3.00	0.061226	0.057799	0.944027	0.059000	0.057799	0.979644
4.00	0.029518	0.060561	2.051657	0.029309	0.060561	2.066287

Table D-31 OFFCOV

TAR = 4.0 CEP = .60

OFFSET	NOM. INT.	TACWAR	RATIO
0.00	0.062500	0.062500	1.000000
0.10	0.062500	0.062481	0.999702
0.25	0.062500	0.062384	0.998136
0.50	0.062500	0.062036	0.992580
0.75	0.062500	0.061463	0.983409
1.00	0.062500	0.060672	0.970759
1.25	0.062499	0.059676	0.954831
1.50	0.062494	0.058488	0.935897
1.75	0.062466	0.057125	0.914499
2.00	0.062369	0.055606	0.891571
2.50	0.061214	0.052184	0.852490
3.00	0.056287	0.048397	0.859826
4.00	0.028992	0.012676	0.437214

TAR = 4.0 CEP = .80

OFFSET	NOM. INT.	TACWAR	RATIO
0.00	0.062500	0.062500	1.000000
0.10	0.062500	0.062475	0.999602
0.25	0.062500	0.062345	0.997528
0.50	0.062499	0.061882	0.990123
0.75	0.062497	0.061117	0.977926
1.00	0.062488	0.060063	0.961197
1.25	0.062459	0.058735	0.940371
1.50	0.062383	0.057151	0.916124
1.75	0.062189	0.055333	0.889763
2.00	0.061745	0.053308	0.863086
2.50	0.059401	0.048746	0.820622
3.00	0.053337	0.043696	0.819244
4.00	0.028582	0.033078	1.157318

TAR = 4.0 CEP = 1.0

OFFSET	NOM. INT.	TACWAR	RATIO
0.00	0.062491	0.062500	1.000144
0.10	0.062490	0.062468	0.999654
0.25	0.062487	0.062303	0.997048
0.50	0.062475	0.061714	0.987817
0.75	0.062442	0.060745	0.972823
1.00	0.062371	0.059414	0.952593
1.25	0.062232	0.057746	0.927913
1.50	0.061937	0.055770	0.900436
1.75	0.061425	0.053522	0.871347
2.00	0.060591	0.051041	0.842389
2.50	0.057101	0.045545	0.797627
3.00	0.050370	0.039625	0.786682
4.00	0.028179	0.027800	.986545

TAR = 4.0 CEP = 1.25

OFFSET	NOM. INT.	TACWAR	RATIO
0.00	0.062343	0.062500	1.002518
0.10	0.0623[illegible]6	0.062063	1.002033
0.25	0.062312	0.062264	0.999287
0.50	0.062233	0.061575	0.989434
0.75	0.062083	0.060439	0.973520
1.00	0.061806	0.058883	0.952709
1.25	0.061362	0.056941	0.927960
1.50	0.060721	0.054655	0.900397
1.75	0.059786	0.052071	0.871538
2.00	0.058259	0.049241	0.845204
2.50	0.053976	0.043060	0.798738
3.00	0.046899	0.036549	0.779321
4.00	0.027537	0.024080	0.874451

Table D-32 OFFCOV

OFFSET	TAR = 4.0 CEP = 1.50 NUM. INT.	TACWAR	RATIO	TAR = 4.0 CEP = 1.175 NUM. INT.	TACWAR	RATIO
0.00	0.061657	0.062500	1.013672	0.062419	0.062500	1.001298
0.10	0.061647	0.062460	1.013192	0.062417	0.062464	1.000754
0.25	0.061592	0.062252	1.010713	0.062403	0.062276	0.997963
0.50	0.061402	0.061513	1.001813	0.062347	0.061608	0.988154
0.75	0.061029	0.060302	0.988085	0.062242	0.060512	0.972202
1.00	0.060502	0.058646	0.969319	0.062054	0.059009	0.950934
1.25	0.059743	0.056563	0.947109	0.061694	0.057132	0.926055
1.50	0.058720	0.054160	0.922351	0.061153	0.054919	0.898053
1.75	0.057239	0.051431	0.898525	0.060340	0.052413	0.868629
2.00	0.055445	0.048451	0.873864	0.059027	0.049664	0.841373
2.50	0.0[illegible]653	0.041986	0.828902	0.054880	0.043639	0.795180
3.00	0.043753	0.035244	0.805529	0.047900	0.037260	0.777864
4.00	0.0268[illegible]	0.022573	0.839574	0.027736	0.024918	0.898411

OFFSET	TAR = 4.0 CEP = 2.0 NUM. INT.	TACWAR	RATIO	TAR = 4.0 CEP = 4.0 NUM. INT.	TACWAR	RATIO
0.00	0.057558	0.062500	1.085861	0.030398	0.039967	1.314784
0.10	0.057545	0.062461	1.085436	0.030390	0.039954	1.314713
0.25	0.057472	0.062259	1.083296	0.030343	0.039888	1.314559
0.50	0.057103	0.061542	1.077743	0.030176	0.039651	1.313997
0.75	0.056496	0.060366	1.068498	0.029899	0.039260	1.313092
1.00	0.055630	0.058756	1.056202	0.029516	0.038719	1.311802
1.25	0.054363	0.056750	1.043912	0.029031	0.038035	1.310136
1.50	0.052915	0.054391	1.027891	0.028448	0.037214	1.308149
1.75	0.051201	0.051729	1.010305	0.027774	0.036268	1.305809
2.00	0.049202	0.048818	0.992203	0.027014	0.035205	1.303216
2.50	0.044343	0.042484	0.958085	0.025272	0.032780	1.297106
3.00	0.038523	0.035848	0.930556	0.023288	0.030043	1.290048
4.00	0.025493	0.023265	0.912584	0.018888	0.024062	1.273907

Table D-33 OFFCOV

OFFSET	TAR = 4.0 CEP = 8.0		
	NUM. INT.	TACWAR	RATIO
0.00	0.009822	0.010000	1.018123
0.10	0.009821	0.009999	1.018125
0.25	0.009816	0.009994	1.018110
0.50	0.009798	0.009975	1.018075
0.75	0.009768	0.009944	1.018025
1.00	0.009726	0.009901	1.017971
1.25	0.009673	0.009845	1.017824
1.50	0.009607	0.009778	1.017815
1.75	0.009531	0.009699	1.017653
2.00	0.009443	0.009609	1.017579
2.50	0.009236	0.009396	1.017304
3.00	0.008990	0.009142	1.016872
4.00	0.008391	0.008525	1.016013

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Armed Forces Radiobiology Research Institute
Defense Nuclear Agency
National Naval Medical Center
ATTN: Director

Assistant to the Secretary of Defense
Atomic Energy
ATTN: Executive Assistant

Command & Control Technical Center
Department of Defense
ATTN: C-315
ATTN: C-343
ATTN: C-312
ATTN: C-332

U.S. European Command
ATTN: J-3
ATTN: J-2
ATTN: J-6
ATTN: J-5NPG
ATTN: J-LW
ATTN: J-2T

Commander in Chief, Atlantic
ATTN: N-22

Commander in Chief, Pacific
ATTN: J-634
ATTN: J-32
ATTN: J-54

Defense Advanced Rsch. Proj. Agency
ATTN: TIO

Defense Civil Preparedness Agency
ATTN: Hazard Eval. & Vul. Red. Div., G. Sisson
ATTN: Deputy Director C.McLain

Defense Documentation Center
12 cy ATTN: DD

Defense Intelligence Agency
5 cy ATTN: DB-4

Defense Nuclear Agency
ATTN: STVL
ATTN: DDST
ATTN: RATN
ATTN: STNA
4 cy ATTN: TITL
2 cy ATTN: VLWS

Field Command
Defense Nuclear Agency
ATTN: FCPR

Field Command
Defense Nuclear Agency
ATTN: FCPRL

Intelligence Center, Pacific
Department of Defense
ATTN: COMIPAC

DEPARTMENT OF DEFENSE (Continued)

Interservice Nuclear Weapons School
ATTN: TTV

Joint Chiefs of Staff
ATTN: J-5, Strategy Division
ATTN: SAGA/SFD
ATTN: J-3, Strategic Operations Div.
ATTN: SAGA/SSD
ATTN: J-3
ATTN: J-5, Nuclear Division

Joint Strat. Tgt. Planning Staff
ATTN: JLAS
2 cy ATTN: JL/JP
2 cy ATTN: JLTW-2

National Defense University
ATTN: ICAF, Technical Library
ATTN: NWCLB-CR

Net Assessment
Office of the Secretary of Defense
ATTN: Military Assistant

U.S. National Military Representative
SHAPE
ATTN: U.S. Documents Officer

Under Secy. of Def. for Rsch. & Engrg.
ATTN: Strategic & Space Systems (OS)

DEPARTMENT OF THE ARMY

Deputy Chief of Staff for Ops. & Plans
Department of the Army
ATTN: DAMO-ZXA
ATTN: DAMO-NC, V. Falter
ATTN: DAMO-NCN, G. Hipp

Harry Diamond Laboratories
Department of the Army
ATTN: DELHD-N-P

U.S. Army Ballistic Research Labs
ATTN: Technical Library
ATTN: DRDAR-BLT

U.S. Army Comd. & General Staff College
ATTN: ACQ Library Division

U.S. Army Concepts Analysis Agency
ATTN: MOCA-WGP

U.S. Army Europe and Seventh Army
ATTN: DCSOPS-AEAGE
ATTN: DCSOPS-AEAGC

U.S. Army Nuclear & Chemical Agency
ATTN: Library

U.S. Army TRADOC Systems Analysis Activity
ATTN: ATAA-TAC

U.S. Army War College
ATTN: Library

DEPARTMENT OF THE ARMY (Continued)

U.S. Military Academy
ATTN: Document Library

DEPARTMENT OF THE NAVY

Naval Postgraduate School
ATTN: Code 0142

Naval Research Laboratory
ATTN: Code 1240

Naval Sea Systems Command
ATTN: SEA-09G53
ATTN: SEA-06J11

Naval Surface Weapons Center
ATTN: Code F31

Naval War College
ATTN: Document Control

Nuclear Weapons Tng. Group, Pacific
Department of the Navy
ATTN: Document Control

Nuclear Weapons Tng. Group, Atlantic
Department of the Navy
ATTN: Document Control

Office of Naval Research
ATTN: Technical Information Services

DEPARTMENT OF THE AIR FORCE

Air Force School of Aerospace Medicine
ATTN: Radiobiology Division

Air Force Systems Command
ATTN: SD
ATTN: XR
ATTN: DL

Air Force Weapons Laboratory, AFSC
ATTN: SUL
ATTN: DYT
ATTN: NSB

Assistant Chief of Staff
Intelligence
Department of the Air Force
ATTN: INA

Deputy Chief of Staff
Research, Development & Acq.
Department of the Air Force
ATTN: AFRDQSM

Foreign Technology Division, AFSC
ATTN: TQR
ATTN: SDN
ATTN: CCN

Strategic Air Command
Department of the Air Force
ATTN: DO
ATTN: NR
ATTN: NRI-STINFO Library
ATTN: ADINDS
ATTN: XP

DEPARTMENT OF THE AIR FORCE (Continued)

U.S. Air Force, Pacific
ATTN: XP

U.S. Air Forces in Europe
ATTN: XPX
ATTN: DEP
ATTN: DOT
ATTN: INT
ATTN: INM

DEPARTMENT OF ENERGY

Department of Energy
Albuquerque Operations Office
ATTN: CTID

DEPARTMENT OF ENERGY CONTRACTORS

Lawrence Livermore Laboratory
ATTN: Technical Information Dept. Library

Los Alamos Scientific Laboratory
ATTN: MS 364
ATTN: T. Dowler

DEPARTMENT OF DEFENSE CONTRACTORS

Advanced Research & Applications Corp.
ATTN: Document Control

Aerospace Corp.
ATTN: Library

BDM Corp.
ATTN: J. Braddock

General Electric Co.
Aerospace Grp. Strat. Planning & Prgms. Ops.
ATTN: R. Minckler

General Electric Co.-TEMPO
ATTN: DASIAC

General Research Corp.
ATTN: Tactical Warfare Operations

Historical Evaluation & Rsch. Org.
ATTN: T. Dupuy

Hudson Institute, Inc.
ATTN: H. Kahn

IIT Research Institute
ATTN: Documents Library

Institute for Defense Analyses
ATTN: Classified Library
ATTN: J. Grote

Jaycor
ATTN: R. Sullivan

Kaman Sciences Corp.
ATTN: F. Shelton

Lovelace Biomedical & Environmental Research Institute, Inc.
ATTN: D. Richmond

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Martin Marietta Corp.
ATTN: F. Marion

Mathematical Applications Group, Inc.
ATTN: M. Cohen

Pacific-Sierra Research Corp.
ATTN: G. Lang

R & D Associates
ATTN: C. MacDonald
ATTN: H. Brode
2 cy ATTN: L. Hanneman
2 cy ATTN: Document Control

R & D Associates
ATTN: J. Thompson

Rand Corp
ATTN: D. Smallwood
ATTN: M. Weiner

Santa Fe Corp.
ATTN: D. Paolucci

Science Applications, Inc.
ATTN: J. Warner
ATTN: Document Control
ATTN: C. Whittenbury
ATTN: M. Drake

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Science Applications, Inc.
ATTN: D. Kaul

Ship Systems, Inc.
ATTN: B. Dunne

SRI International
ATTN: M. Earle

System Planning Corp.
ATTN: J. Douglas

Systems, Science & Software, Inc.
ATTN: J. Cane
ATTN: J. Northrop

Tetra Tech, Inc.
ATTN: F. Bothwell

TRW Defense & Space Sys. Group
ATTN: P. Dai

Science Applications, Inc.
ATTN: Document Control
ATTN: W. Layson